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National Emission Standards for Asbestos— Background Information for Proposed Standards

Emissions Standards and Engineering Division

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Metric Conversion Factors (Approximate)

Symbol	When You Know Number of	Multiply By	To Find Number of	Symbol
		LENGTH		
in	inches	2.54	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		WEIGHT (mass)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2,000 pounds)	0.9	metric tons	t
		VOLUME		
tsp	teaspoons	5	milliliters	mL
Tbsp	tablespoons	15	milliliters	mL
in^3	cubic inches	30	milliliters	mL
fl oz	fluid ounces	30	milliliters	mL
c	cups	0.24	liters	L
pt	pints	0.47	liters	L
qt	quarts	0.95	liters	L
gal	gallons	3.8	liters	L
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		PRESSURE		
inHg	inches of mercury	3.4	kilopascals	kPa
psi	pounds per square inch	6.9	kilopascals	kPa
		TEMPERATURE (exact)		
°F	degrees Fahrenheit	5/9 (after subtracting 32)	degrees Celsius	°C

Source: U.S. Department of Commerce. Metric Style Guide for the News Media. National Bureau of Standards. Washington, DC, n.d.

3.0 THE ASBESTOS INDUSTRY

3.1 GENERAL

The asbestos industry involves a wide range of operations, including mining the ore, milling the ore to obtain raw asbestos fibers, manufacturing asbestos-containing products, and fabricating asbestos-containing products for a variety of applications. All of these operations have the potential of releasing asbestos fibers to the atmosphere. Apparent U.S. asbestos consumption was 48,000 Mg in 1989.[1] Other activities not strictly a part of the asbestos industry that have the potential of releasing asbestos fibers to the atmosphere include construction, demolition, and renovation of buildings or structures that contain asbestos and disposal of asbestos-containing waste. The following paragraphs briefly describe each of these operations and activities, including an estimate of 1989 nationwide emissions. Emission estimates are presented in Section 3.4.

3.1.1 <u>Mining</u>

In 1985, three asbestos mines were operating in this country--two in California and one in Vermont. None of the three mines is located in large population centers.

3.1.2 <u>Milling</u>

The three mining sites operating in the United States in 1985 also operated the only three mills in this country.

Annual emissions from milling are estimated to be 330 kg (730 lb).

3.1.3 <u>Asbestos Paper Manufacturing</u>

Asbestos paper products, which are used in a wide variety of applications, are produced on papermaking machines. Paper products can be grouped into several categories, including flooring felt, roofing felt, beater-add gasketing paper, pipeline wrap, specialty papers, millboard and rollboard, commercial paper, and electrical paper. Flooring felt alone accounts for nearly 50 percent of total asbestos consumed in paper products. Asbestos consumed by flooring felt, roofing felt, and beater-add gasketing paper accounts for nearly 90 percent of total asbestos consumed in asbestos paper products.

Annual emissions from paper manufacturing are estimated to be 8 kg (18 lb).

3.1.4 Asbestos Friction Materials Manufacturing

Asbestos friction materials include drum brakes, disc pads for disc brakes, brake blocks, clutch facings, and industrial linings for manufacturing equipment. The largest segment of asbestos friction material shipments by value is drum brake linings (molded and woven),[2] although disc brakes are becoming more popular.

Emissions from friction product manufacturing are estimated to be 500 kg/yr (1,100 lb).

3.1.5 Asbestos Cement (A/C) Products Manufacturing

A/C products manufactured in the United States usually fall into one of two categories: sheet (including cement or silicate) or pipe. However, a small market exists for A/C molded and extruded products.

Estimated annual emissions from the production of A/C pipe and A/C sheet are 40 and 30 kg (89 and 67 lb), respectively.

3.1.6 Vinyl/Asbestos (V/A) Floor Tile Manufacturing

V/A floor tiles are manufactured from filled polyvinyl chloride (PVC) polymers or copolymers. They are produced in squares usually 23 cm by 23 cm (9 in. x 9 in.) or 30 cm x 30 cm (12 in. x 12 in.) with thicknesses varying from 0.1 cm to 0.2 cm (1/32 to 3/32 in.). V/A floor tiles are widely used because of ease of installation and maintenance, durability, and rot resistance. Tiles are fastened down with asphalt-based adhesives or a self-sticking adhesive that is put on at the manufacturing facility and covered with release paper.[3]

Emissions from the production of V/A floor tile are estimated to be 8 kg/yr (18 lb/yr).

3.1.7 Asbestos-Reinforced Plastics Manufacturing

Asbestos-reinforced plastics are polymeric materials to which asbestos fibers are added to modify the composite's physical and chemical characteristics. These composite materials are multicomponent blends in which the asbestos fiber is the load-carrying member, and the polymeric matrix fills the gaps between the fiber and distributes the applied stress to the fibers. The plastic material provides a shape and a smooth surface to protect the fibers and also may provide thermal or electrical resistance. Asbestos fibers are used to reinforce phenolic, polyester, and epoxy resins and in a wide range of thermoplastic polymers.[4]

Primary applications of asbestos-reinforced plastics are V/A and asphalt floor tiles, friction materials, and gasketing,[5] discussed separately in sections specific to these product categories. Phenolic molding compounds are the major asbestos users in reinforced plastic applications other than the above primary applications.[6] In this section, discussion is limited to phenolic molding compounds.

Major markets for phenolic molding compounds are automotive, printing, household appliances, and electronics. Other markets include wiring devices, communications, and closures.[7]

Annual emissions from plastics manufacturing are estimated to be 30 kg.

3.1.8 Asbestos Coatings and Sealants Manufacturing

Asphalt-asbestos coatings represent the major product in this industry segment. Industrial, construction, and automotive industries use these coatings to protect metals from corrosion, to insulate pipes and tanks, and to control sound. They have a variety of uses as undercoatings for automobiles, flashing cements, tile cements, and roof coatings, but they are primarily used for the latter.[8]

The manufacture of asbestos coatings and sealants emits an estimated 20 kg/yr (44 lb/yr) of asbestos.

3.1.9 Asbestos Gaskets and Packings Manufacturing

Gaskets and packings are used to prevent fluid leakage in applications such as valves and pump tank sealing devices. Asbestos is the most widely used material for gaskets and packings because of its resilience, strength, chemical inertness, and heat resistance.[9]

Manufacturers of beater-add gasketing paper use a papermaking process and are excluded from this category. Beater-add gasketing is discussed in Section 3.1.3, Asbestos Paper Manufacturing.

Emissions from the manufacture of gaskets and packings are estimated to be 1 kg/yr (2 lb/yr).

3.1.10 Asbestos Textiles Manufacturing

Asbestos fibers may be worked into a textile form to provide an incombustible material that retains its physical properties at high temperatures. Asbestos textiles are manufactured in several different forms and have various uses, including:

- Lap--used as insulation for electrical conductors
- Roving--used as insulation for heater cords, twisted to form yarn
- Yarn--woven into textiles
- Cord--used for seals, packings, and insulation
- Cloth--used for curtains, blankets, and safety clothing
- Tubing--used for sleeving for electrical conductors
- Wick--used as packings and sealings
- Tape--used for electrical insulation.[10]

Textile asbestos emissions are estimated to be 3 kg/yr (7 lb/yr).

3.1.11 Chlorine Manufacturing

Of the chlorine produced in this country, 70 percent is produced by diaphragm cells, and an approximate total of 0.1 kg of asbestos is consumed per megagram of chlorine produced (0.25 lb of asbestos consumed per ton of chlorine produced).[11,12,13] Over half of the chlorine plants in the United States produce chlorine by the diaphragm cell process.

No data are available to estimate asbestos emissions from the production of chlorine, although emissions are considered small relative to emissions from asbestos product manufacturers.

3.1.12 Shotgun Shell Manufacturing

Asbestos was once used to manufacture base wads for shotgun shells. However, given the availability of substitutes for asbestos wads, this market has disappeared. Thus, an emission estimate was not made for this category.

3.1.13 Asphalt Concrete Batching

Asbestos added to asphalt gives it greater strength and longer life and has been used as a thin topping layer on some airport runways, bridges, and street curbing.[14] As of 1974, there were an estimated 5,000 asphalt concrete plants in the United States, about 50 of which used asbestos. A total of 4,100 Mg (4,500 tons) of asbestos were used.[15] By 1978, asbestos use in asphalt concrete was less than 91 Mg (100 tons) per year as a result of environmental restrictions and concerns over health effects and Government regulations,[16] most likely regulations from EPA and Occupational Safety and Health Administration (OSHA). Current asbestos use in asphalt concrete is negligible and its continued use is unlikely.[17] In 1981, the National Asphalt Pavement Association (NAPA) was not aware of any asphalt concrete plant that uses asbestos.[18]

Emissions from asphalt concrete production were not estimated, but because of negligible asbestos consumption, emissions are insignificant.

3.1.14 Asbestos Product Fabrication

Asbestos product fabrication refers to operations that use products from primary manufacturers and fabricate them into end products or for some final use. In many cases, primary manufacturers fabricate their own products or the products of other primary manufacturers. These activities are dealt with in the discussion of the primary manufacturing processes and include operations such as the application of a vinyl coating to flooring felt to form a completed floor covering and the use of asbestos paper to form gaskets.

Field fabrication of asbestos products is sometimes required, which involves occasional cutting and machining of A/C pipe and A/C sheet during installation of a pipeline or at a construction site and cutting of roofing and flooring products during installation. The fabrication categories currently covered by the national emission standard for hazardous air pollutants (NESHAP) include fabrication of A/C building products, of A/C or asbestos-silicate boards, and of friction materials. Other categories include fabricators of paper products, plastics, and textiles. Emissions from fabrication sources covered by the NESHAP are estimated to be 60 kg/yr (130 lb/yr).

3.1.14.1 A/C Products.[19] Many A/C sheets come from the manufacturer ready for use; however, specialized applications of A/C sheet (e.g., laboratory tabletops, fume hoods, heat shields, and mounting panels for electrical switches) require secondary processing. Much of the secondary processing is done by distributors, job shoppers, or fabricators who are located throughout the country. End users usually do not fabricate A/C sheet because trade unions or corporate management often prohibit workers from fabricating A/C sheet on-site. Some corporations have banned any use of asbestos-containing materials in their products.

A/C sheet fabricators generally service particular markets (e.g., some fabricate mostly fume hoods and laboratory tabletops, while others distribute and fabricate construction products) and generally distribute and fabricate asbestos substitutes as well as asbestos-containing materials, with the trend over the past 4 to 5 years being toward more substitutes.

3.1.14.2 Asbestos Friction Materials.[20] Fabricators of friction products include secondary fabricators and the automotive aftermarket. Most secondary fabrication of friction products is performed by the primary manufacturers, either in the primary manufacturing plant or at a separate location. Some friction products are sold to secondary fabricators who produce components such as clutch facings and brake pads, mostly for sale in the automotive and industrial and commercial aftermarkets.

The collection of industries known as the automotive aftermarket is composed of companies that remanufacture, distribute, and install replacement parts to service and repair the Nation's motor vehicles, primarily the remanufacturer of brake linings and clutch plates. At one time, automatic transmissions were rebuilt with parts containing asbestos material; however, in recent years, automatic transmissions have switched to small throwaway clutch discs and away from the large rigid bands that can be resurfaced.

Remanufactured parts are distributed to retail outlets for installation on motor vehicles. The retail outlets include motor vehicle dealers; tire, battery, and accessory shops; gasoline service stations; and general automobile repair shops. The movement of parts from the remanufacturing facilities to the retail outlet is performed by distributors. The distributors act as a clearinghouse and storage center for the remanufactured parts before delivery to retail outlets. The parts are usually individually boxed at the remanufacturing facility and generally are not reopened or repackaged at the distribution centers.

The general service and repair sector of the automotive aftermarket is very large and involves a number of subsectors. Estimated establishments involved are:

Repair shops	86,991
Dealerships	25,641
Tire/battery/accessories	35,986
Service stations	136,570
Total	285,188

3.1.14.3 Asbestos-Reinforced Plastics. Primary industry segments manufacture molding compounds, mainly phenolic molding compounds, and sell this granulated material to a myriad of secondary molding fabricators. Major segments of this secondary industry include household appliances, utensils, and tools; various automobile applications in the ignition, transmission, and wiring system; the wiring device industry; electrical switch gear manufacturers; makers of closures such as bottle and jar caps; and the communications and electronics industry. Some of the primary industries fabricate their own plastic products, but, for the most part, asbestos-reinforced plastics go through secondary processes.

3.1.14.4 Asbestos Paper Products. Asbestos paper is used in areas such as roofing, gaskets (commonly called beater-add gaskets), thermal and electrical insulation material, and underlaying for sheet flooring. Many primary manufacturers of asbestos paper also fabricate and finish the product for sale to the end user. Specifically, manufacturers of asbestos roofing felt have their own saturating plants, which in turn sell the roofing product directly to the construction industry. Individual establishments acting as secondary fabricators of asbestos roofing products are minimal. A significant portion of asbestos paper goes directly into the secondary fabricators for gasketing material. Other paper is sold to manufacturers of cooling towers where the paper is saturated, cut, and fabricated as a sandwich filler for some applications.

Based on sales data from primary manufacturers, an estimated 60 percent of asbestos paper goes through some form of secondary fabrication before reaching the construction industry or other end users.

3.1.14.5 Asbestos Gaskets, Seals, and Packings Materials. During secondary fabricating steps, gaskets and packings materials may be impregnated with polymers, latex, or other chemicals to impart certain properties to the material. Secondary fabricators cut, slit, or punch the material to specific shapes for end users. Where strength and pressure sensitivity are not critical, gasket cutters use asbestos paper from the paper segment of the primary asbestos industry. Finally, asbestos yarns made by primary asbestos textile mills are sold to secondary fabricators to be used as packings material for pumps and other applications that require this high-strength material. In some instances, primary textile operations will manufacture their own packings material and sell it directly to end-user industries.

Based on sales data from primary industries, approximately 95 percent of gaskets and packings material are estimated to go through secondary fabricating firms.

3.1.14.6 Asbestos Textiles. The wide range of asbestos textiles has a correspondingly wide range of secondary markets. Asbestos cloth has been used in welding curtains and screens, safety garments, protective clothing, and reinforced plastic laminates. Asbestos yarn is still used to a limited degree in the wire and cable industry. Asbestos yarn is used in braided packings and is woven in the process of making certain clutch facings and brake linings for industrial applications.[21]

With some large textile companies, fabricating certain products may occur within the primary textile industries. However, for the most part, asbestos textiles go through secondary fabricating steps prior to end use. For this reason and based on sales data, it is estimated that approximately 90 percent of the asbestos textiles manufactured by the primary segment go through secondary processing.

3.1.15 Construction Industry

In 1977, 1.2 million establishments were operating as general building contractors and operative builders (SIC 15), heavy construction contractors (SIC 16), special trade contractors (SIC 17), and subdividers and developers (SIC 6552).[22] Of the 1.2 million establishments, 70 percent were special trade contractors, 24 percent were general builders, 5 percent were involved in heavy construction, and 1 percent were subdividers and developers.

General building contractors and operative builders are involved in residential and nonresidential construction that includes dwellings, stores, farm buildings, and office buildings. General contractors perform services either under contract with the project owner or under the operative builder who undertakes projects to be sold. Heavy construction general contractors are involved in highway and street construction;

bridge, tunnel, and elevated highway construction; water, sewer, and utility projects; dams and water projects; airfields; heavy industrial facilities; and other heavy construction that involves either earth moving or erecting constructions and appurtenances other than buildings.

Special trade contractors are involved in specialized activities such as plumbing, heating, and air-conditioning; painting, paper hanging, and decorating; electrical work; masonry and other stonework; plastering, drywall, and insulation; terrazzo, tile, marble, and mosaic work; carpentry; roofing and sheet metal work; concrete work; water well drilling; structural steel erection; glass and glazing work; excavating and foundation work; and wrecking and demolition. Special trade contractors may work for general contractors under subcontract or directly for the project owner. Subdividers and developers are primarily engaged in subdividing real property into lots and in developing it for resale for their own account or for others.

Regardless of the types of construction work and business, certain fundamental characteristics are shared among various industry classes. Some of these characteristics can be summarized to define the industry further:

- Construction work is performed at temporary locations that vary in size, physical boundaries, and working surfaces.
- Construction work is usually performed in open air, subject to weather variability.
- Construction work varies as the project progresses from initiation to completion, demanding a variety of materials, equipment, and skills.
- Type and duration of emissions are variable due to the significant influence of wind and atmospheric conditions.
- Portable tools and equipment are preferred on temporary locations and for fieldwork, making local exhaust ventilation (LEV) and dust collection a major engineering problem.
- Employment is transient in construction, permitting tradesmen and laborers to work for several different contractors at several different sites per year.

3.1.16 Renovation

Under Section 61.141 of the asbestos emission standard, renovation has been defined as "altering in any way one or more facility components."

Wrecking or removal of load-supporting structural members is excluded. Therefore, removal of insulation materials containing asbestos and removal of sprayed-on asbestos-containing materials for remodeling, repair, or renovation (operations as described by the construction industry) come under the standard's purview. However, as the standard stipulates, only removal or stripping of friable asbestos materials amounting to that covering more than 80 m (linear) of pipe or that covering more than 15 m^2 on facility components is regulated. The Administrator excluded from the scope and application of the standard all residential buildings except private multiunit dwellings with more than four units.

Portions of the construction industry that would engage in "renovating operation" (as defined in the standard) are general contractors of residential but not single-family buildings; general contractors of nonresidential buildings that include industrial buildings and warehouses; and general contractors who engage in new construction, addition, alteration, remodeling, and repair of commercial, institutional, religious, amusement, and recreational buildings. There are also contractors who specialize in asbestos abatement work. In addition, the following special trade contractors would most likely engage in renovation:

- Plumbing, heating (except electric), and air-conditioning
- Electrical work
- Plastering, drywall, acoustical, and insulation work
- Roofing and sheet metal work
- Wrecking and demolition
- Installation or erection of building equipment not elsewhere classified (includes contractors who dismantle industrial equipment)
- Special trades not elsewhere classified (includes insulation of pipes and boilers and dismantling of forms of poured concrete).

The special trade contractors not elsewhere classified include contractors engaged in waterproofing, damp-proofing, and fireproofing that may require renovating as defined by the standard.

Due to the high level of control used in most renovation operations, emissions from renovation are estimated to be only about 542 kg/yr (1,200 lb/yr).

3.1.17 Demolition

In 1979 under a "New Directions Grant" from OSHA, a demolition industry profile was prepared.[23] The profile showed that 2,300 companies in the United States are involved in demolition as opposed to the 836 reported in 1972 and the 978 reported in the 1977 Census of Construction Industries. The researchers used a variety of sources but found over 1,600 firms advertising demolition services in telephone directories of 157 cities. They estimated that approximately 2,300 firms were capable of demolition work. An estimate made in the mid-1980s puts the number of firms at nearly 2,500.[24]

Primary data showed that most of the demolition firms--approximately 68 percent--provide a full range of industrial, commercial, and residential structure demolition. The remainder are involved in specialized jobs, such as chemical plants, port facilities, or utilities equipment. The report characterized demolition work by short-term jobs and substantial subcontracting.[25]

The survey showed that the average firm employs 12 permanent and 10 temporary workers and that the average duration of demolition projects is 3.9 days for a residence, 9.6 for a commercial structure, and 14.7 for an industrial facility.

According to the background information document (BID) for the 1973 asbestos emission standard, 4,000 apartment buildings and 22,000 commercial or industrial buildings are demolished annually.[26] However, according to previous EPA estimates, fewer than 3,000 demolitions per year are covered by the standard.[27] For verification, EPA regional NESHAP officers indicated that an estimated 2,618 demolition projects covered by the standard are completed in a year.[28] Further investigation revealed that contracts were awarded for demolition of 2,596 buildings in 1978.[29] Data were not available on the number of these that involved asbestos.

Estimates of nationwide emissions from demolition are 65 kg/yr (144 lb/yr).

3.1.18 Asbestos Waste Disposal

Asbestos-containing waste is generated by almost all of the operations discussed in the preceding paragraphs. Asbestos mills are the largest individual producers of asbestos waste. Asbestos mill waste consists of the remains of the asbestos ore after the asbestos has been removed (mill tailings). Tailings produced by domestic asbestos milling are deposited by conveyor belts onto large tailings piles. They usually are dumped wet onto the piles to prevent emissions. Attempts to vegetate the surface of tailings piles have met with limited success due to the high alkalinity of the tailings and the expense of hauling in sufficient soil cover with which to establish vegetation. Chemicals have been added to wet tailings prior to dumping that help bind the particles and help the tailings resist wind erosion. Upon drying, some tailings form a protective crust-like cover that resists erosion and protects underlying material. In some instances, tailings piles from the milling of long-fiber asbestos ores are self-stabilizing because of the low percentage of fine dust, the tendency of meteorological conditions to form a layer of larger particles that protect the pile's interior, and the consolidation of the pile by freezing during much of the year.[30] Estimated annual emissions from waste disposal at mills are 22 kg/yr (49 lb/yr).

Asbestos-containing waste from manufacturing and fabricating operations is in much smaller quantities than waste from asbestos mills. Most manufacturing, fabricating, demolition, and renovation wastes containing asbestos are disposed of at landfills. A 1981 report by JRB Associates indicated approximately 12,677 sanitary landfills and 44 hazardous waste landfills in the United States.[31] It is likely that asbestos waste is accepted by all 44 hazardous waste landfills. In addition, a number of sanitary landfills, both privately and publicly owned, have been granted approval to accept asbestos waste.

Although most manufacturing wastes are disposed of at these landfills, some plants operate their own on-site landfill for disposal of their asbestos waste. Plants that are most likely to operate their own landfill are those that produce the greatest quantities of waste, such as A/C pipe plants and friction material manufacturing plants. Total waste generation by manufacturing operations is estimated to be 12,200 Mg (13,400 tons) per year. Estimated annual emissions from waste disposal at manufacturing and fabricating sites are 10 kg/yr (22 lb/yr).

Asbestos waste generated by demolition and renovation activities is estimated to be an average of 5.7 million m^3 (7.5 million yd^3) per year.

Estimated annual emissions from demolition and renovation waste disposal are 250 kg/yr.

3.1.19 Asbestos Drilling Fluids

Asbestos is used by the petroleum industry as an additive in well drilling fluids. The asbestos acts mostly as a viscosifier, which enhances the hole-cleaning properties of the drilling mud. Up-to-date information on current usage of asbestos in drilling muds was not identified. A 1978 publication by the American Petroleum Institute indicates that approximately 8,600 Mg (10,000 tons) of asbestos were used for that purpose in 1977.[32] The September 1982 issue of Drilling Contractor[33] indicates that the average number of active drilling rigs in 1977 was 2,002. Asbestos usage in 1977 therefore can be expressed as approximately 4.5 Mg (5 tons) per active drilling rig. If it is assumed that this usage rate has remained constant, asbestos usage for drilling muds in 1982 can be estimated at 13,720 Mg (15,245 tons) based on 3,049 active drilling rigs.[34] However, another study indicates that asbestos usage in drilling muds was declining and may have been as low as 4,600 Mg (5,000 tons) in 1980.[35]

3.1.20 Manufacture of Fireproofing and Insulating Materials

Asbestos has been used as an ingredient in materials used for thermal insulation, acoustical insulation, and fireproofing. Asbestos-containing products used as insulation include asbestos millboard and rollboard, asbestos commercial papers, asbestos cements, asbestos blankets, asbestos coatings and sealants, sprayed asbestos insulation, and molded products. Friable insulating materials were banned by EPA and are no longer manufactured. Spray-on materials containing commercial asbestos are no longer manufactured and have been replaced by nonasbestos materials. Because these materials are no longer manufactured, no further discussion of them is presented in this chapter. Asbestos millboard, rollboard, and commercial papers are paper products and are discussed in Subsection 3.1.3. Asbestos blankets are textile products, which are discussed in Subsection 3.1.10. Asphalt and tar-based coatings and sealants to which asbestos is added have insulating properties. Asbestos coatings and sealants are discussed in Subsection 3.1.8.

3.1.21 Removal and Recycling of Asbestos Pavement

Asphalt pavement topping containing asbestos fibers was laid in the 1960s and 1970s. Typical asbestos content was 2 to 3 percent by weight, topping thickness was 19 mm (3/4 in.), and life was about 10 to 13 years.[36,37] After its useful life, the pavement may be covered with more layers of paving, milled to provide a smooth surface for extended life, or broken up and discarded to make way for new paving.[38] Sometimes, when pavement is to be resurfaced, a milling machine is used to remove the top surface of the existing pavement. The milling machine is self-propelled and has a drum with tungsten-carbide-tipped teeth that extend about 6.35 cm (2.5 in.). Tooth spacing determines the roughness of the road surface after milling. Although milling was formerly practiced as a dry operation, essentially all milling machines now have water sprays to suppress dust. The material removed from the road surface by the milling machine is in chunks of up to 6.35 cm (2.5 in.), which are swept up by a mechanical sweeper that pushes the chunks into a funnel arrangement and onto a conveyor for loading into a truck. The sweeper and conveyor are attached to the milling machine. Dust that is generated during the milling is swept up with rotary sweepers that push the wet dust to the side of the road. In urban areas, the sweeper is followed by a powered vacuum that collects the dust for disposal. In nonurban areas, the wet dust is left by the roadside. The wet debris is collected and recycled through a hot asphalt plant (in most States) or disposed of in a licensed landfill (in some northeastern States).[39,40]

A typical removal operation entails wet-sawing pavement into large areas, then tearing out the pavement between saw cuts with a backhoe or similar equipment. For smaller jobs, jackhammers may be substituted for saws. The chunks of debris are loaded into trucks with front-end loaders and transported to a batch plant for recycle or to a landfill. Debris and wet dust from the sawing operation are swept by hand or by mechanical sweeper and included with other debris.

Pavement removal is also accomplished by using a motor grader or bulldozer to rip up the desired pavement into large chunks. If the paving is to be recycled, heavy equipment is run over the broken roadway to reduce the size of the chunks. A front-end loader is then used to dig out the resulting chunks of paving and load them onto a truck for transport. If not recycled, the chunks may be disposed of in a landfill or may be used as fill for nearby highway construction sites.

Potential sources of asbestos emissions would include the sawing, milling, and sweeping operations. The pavement-breaking operation probably does not contribute much to asbestos emissions.[41] It is not clear if the use of jackhammers would produce significant asbestos emissions.

3.1.21.1 Recycle Operations. Almost all new asphalt plants are drum mixer rather than batch plants. The sequence of operations in a batch plant is: cold aggregate feed to aggregate drier to bucket conveyor to screening to hot hopper bins to pug mill mixer, where asphalt is added to make up the batch.[42] The drum mixer plants have no conveyor, screens, hot bins, loading hopper, or pug mill. In batch plants, the drier uses a counterflow of aggregate and combustion gases, with the burner at the low end of the drier. In drum mixers, the burner is at the high end and flow is co-current. Virgin aggregate is fed at the top of the drum, recycled asphalt pavement (RAP) is fed in the middle, and asphalt is added in the last third. The virgin aggregate is "superheated" near the burner end to remove water and to retain heat for melting asphalt in the RAP and for keeping the mix hot after it leaves the drum and while it is in storage or transfer. Final heating to about 135 to 154 °C (275 to 310 °F) is achieved in the paving machine. Typical sizes for the drum mix plants are from 45 to 405 Mg/hr (50 to 450 tons/hr) of paving mix.

The RAP brought from a repair site to the asphalt plant is stored in low stockpiles (high piles would promote unwanted bonding of the pavement chunks). When needed for addition to new mixes, the material is removed from the stockpile with an end loader and dumped onto a conveyor for loading into the drum. The conveyor is equipped with a load cell for weighing the amount of RAP that is added to the mix. Typically, the amount of RAP used is from 15 to 25 percent, but may go higher or lower. Within specifications established by the customer for a maximum amount of RAP, the asphalt plant operator uses an amount that gives him the best economic balance between the cost of extra fuel to remove water from wet RAP and the savings obtained in using recycled material instead of virgin aggregate. The RAP asphalt and aggregate characteristics are also factored into the economic balance.

The only difference between recycling milled pavement and removed pavement is in the treatment of the paving chunks delivered to the asphalt plant. The milled paving chunks are about 3.8 cm (1.5 in.) thick and can be used directly, but the removed chunks are larger and must be crushed to the 3.8 cm (1.5 in.) size. A rotary crusher at the plant performs this operation.

Controls for the plant are usually baghouses or scrubbers on the drum mixer. For portable plants, the control is more likely to be a scrubber because baghouses are harder to transport. Federal particulate standards (New

Source Performance Standards) [NSPS]) for the plants are 0.04 gr/dscf and 20 percent opacity. Particulate matter emission points are controlled either by dust suppression techniques or by hooding and ducting to the control device. Asphalt plants now tend to be very clean.[43] There is no longer the layer of fine dust that formerly was found coating everything at the plant.

Potential sources of asbestos emissions would include loading, unloading, and conveyor operations, as well as grinding and sizing. Loading includes transfer of material to the mixer, but not the actual mixing because the hot asphalt coats and retains dust in the mixer.

3.1.21.2 Controls for Removal Operations. Controls for removing asbestos pavement at road sites can include dust suppression measures, primarily wetting, for sawing and sweeping. Debris can be vacuumed and loaded wet, and trucks should be covered. All of these techniques are now practiced to some extent.

3.1.21.3 Controls for Recycle Operations. Dust suppression techniques can be used for loading, unloading, and conveying. Hoods and dust collectors (scrubbers or, preferably, baghouses) can be used wherever installation is feasible. These techniques are now generally practiced.

3.1.21.4 Locating Existing Pavement. Two methods of locating asbestos-containing pavement exist: surveying records and testing pavement. Locating records may be difficult for many cases. Records for paving jobs that were performed 20 to 30 years ago may have been kept at State, county, and city levels. However, it is uncertain and in many cases unlikely that the records will contain information about the type of mix used for the paving. Contacts with the Federal Highway Administration,[44,45] NAPA,[46] and city road and street officials[47,48] suggest that finding information will be difficult. Even for locations in which it is known that asbestos paving was used, the current officials are not aware of it.[49]

Another problem with the use of records for locating existing paving is the amount of recycling that has taken place in most of the country. No new asbestos asphalt paving has been laid since the early 1970s. Since that time, most of the existing topping has been recycled or discarded.[50] When asphalt is recycled, it does not necessarily go back to the site from which it came. Each time a length of roadway is recycled, the asbestos it contains may be distributed to new sections of paving. In these cases, no records would exist of the asphalt origin or of its containing asbestos.

To make positive identification of asbestos, it is likely that any paving being discarded or recycled would have to be sampled and tested for asbestos. Low-temperature ashing and observation under an optical microscope would be an appropriate method costing about \$100.[51] However, contact with the Asphalt Institute[52] suggests that, after the passage of so much time since asbestos was used in paving, fiber levels would be too low to detect and that there might be confusion caused by background levels of asbestos found in some aggregates. Sampling and sample transport would add to the cost, although core samples that are now routinely taken may be usable for asbestos determinations.

It is estimated that 16,000 km (10,000 miles) of topping were laid up to the middle 1970s. For an average 10.4-m (34-ft) road width and a density of 2,498 kg/m^3 (156 lb/ft^3) for asbestos, total asbestos content of the roadway would be 198 Mg (220 tons). Emissions from removal or recycling of remaining roadway are expected to be small. NAPA believed that no statistics are available on the number of miles of street and highway repair and surfacing done each year because of the many different types of roadways and types of governments overseeing them.[53] However, for 1989, the amount of hot-mix asphalt used was 441 million Mg (490 million tons). Of this amount, 85 percent was used for paving and the remaining 15 percent was used for other purposes such as sealing. The hot-mix used for paving could be for anything from resurfacing at depths as small as 1.27 cm (0.5 in.) to new roadway at 15.2 cm (6 in.).

To make a rough estimate of the distance represented by the 375 million Mg (416.5 million tons) of paving material, it was assumed that all the mix was laid at a thickness of 7.6 cm (3 in.), a width of 10.2 m (34 ft), and a density of 2,400 kg/m^3 (150 lb/ft^3). With these assumptions, the equivalent annual mileage for asphalt paving and repair in the United States would be about 198,400 km (124,000 miles). The estimated 16,000 km (10,000 miles) of asbestos-asphalt paving represents about 8 percent of the estimated annual repair and resurfacing performed in the United States, and about 0.25 percent of the more than 6.4 million km (4 million miles) of roadway in the United States.[54]

3.2 ASBESTOS INDUSTRY PROCESSES AND EMISSION SOURCES

This section discusses processes and emission sources including uncontrolled emissions. Uncontrolled emissions are hypothetical only because the asbestos industry is generally well controlled. As such, they give an indication of what emissions could be in the absence of controls. Emissions were estimated because EPA has not developed a method for quantifying the asbestos content of the small amount of particulate collected through particulate sampling methods.[55] The methodology used to estimate emissions is discussed in Section 3.4.

3.2.1 Mining

The asbestos content of ore bodies varies with location, from 2 to 3 percent asbestos by weight at the Vermont mine to 60 percent at Union Carbide's mine in San Benito, California. Surface mining methods are used where the asbestos-containing ore lies near the surface and is not bound within massive rock deposits. Such ore can be bulldozed or removed by a power shovel, a method used at the Union Carbide mine. An initial size classification step also is carried out at the site. In Vermont and the Copperopolis district of California, open pit mining is used, and blasting is required to loosen the overburden for removal. Holes are drilled for placement of explosives. Secondary blasting may follow primary blasting to reduce large boulders to manageable size. The ore is loaded by mechanical shovels into overhauling trucks and transported to a stockpile at a primary jaw crusher. In an Arizona mine that is now closed, asbestos deposits were in narrow veins extending far below the surface, requiring underground mining. The ore was freed by drilling and blasting, and the fiber was mined in drifts and stopes through a modified room and pillar method.[56]

Potential emission sources during mining include drilling, blasting, bulldozing, loading ore into hauling trucks, hauling ore and other traffic within the mine, initial processing at the mine site, and dumping ore in stockpiles at the mill. Emissions will be influenced by meteorological conditions, with wet conditions helping to reduce emissions in most mine activities. Ores with high moisture content will be less likely to produce emissions due to disturbances such as wind, loading, and dumping. Data for making emission estimates were not available.

3.2.2 Milling

Asbestos milling is a complex operation primarily involving separation of fiber from rock and classifying fiber by length; the basic method has changed little.[57] The following description of asbestos milling is excerpted from Control Techniques for Asbestos Air Pollutants.[58]

Separation of asbestos fibers from rock typically is initiated by conveying mine ore by a large hopper and pan feeder to a primary, jaw-type crusher that accepts boulders up to 122 cm (48 in.) in diameter and reduces these to fragments not larger than 15.2 cm (6 in.) in diameter. Subsequently, this crushed rock is transported by belt conveyor to trommel screens, which are rotating cylinders with various-sized openings, or to a stationary-bar grizzly, a type of screen, for the sizing operation. Ore fragments greater than 3.1 cm (1-1/4 in.) in diameter are routed to a secondary cone-type crusher for further reduction, and outputs of primary and secondary crushers are conveyed to a wet-ore storage pile exterior to the mill. This stockpile usually contains sufficient ore to sustain mill operations for an extended time.

Wet ore is extracted from the bottom of the wet-ore stockpile by a vibrating-chute feeder in an underground tunnel. The wet ore enters slowly rotating cylindrical dryers that permit baffles internal to the dryers to pick up and release the wet ore continually, thereby exposing it to a drying current of hot air.

The dried ore is conveyed by belt to a vibrating screen that sizes the ore for fine crushing. The undersized screenings and the output of the final crushers form a dry-rock stockpile, which is housed to protect it from the exterior environment.

The finely crushed, dried asbestos ore next traverses a rock circuit, where it undergoes several screenings, fiberizing, and aspiration to remove freed fibers and further disintegrate rock. The principal purpose of this set of operations is to separate asbestos fibers from rock, but the circuit secondarily functions to grade fibers according to length.

In the rock circuit, cleaned rock is finally expelled to an exterior tailings dump. As the airstreams that convey aspirated asbestos fibers pass through cyclone collectors, the fibers are removed for cleaning and additional grading. Exhausts from these collectors are vented to gas-cleaning devices.

Fiber-cleaning circuits are intended to perform additional fiber opening, to classify and separate opened fibers from rock and unopened material, and to carry out further fiber-length grading. Grading, screening, aspirating, and opening are involved in this circuit; in addition, some material is rejected as waste. The aspirated asbestos fibers are deposited into cyclone collectors and subsequently delivered to the grading circuit as long, medium, short, and extra-short fibers. Cyclone exhausts are directed to a gas-cleaning device.

Asbestos fibers are separated into numerous standard grades and cleansed further in the grading circuit. Standard grading machines affect additional opening of fibers and facilitate shorter fiber removal. Air aspiration from vibrating screens separates additional fine dust, fine rock fragments, and unopened fibers. Cyclone collectors are exhausted through fabric filters to control asbestos-containing dusts. Asbestos fibers are machine packaged either by compressing the material into a dense bundle or by blowing this material into bags.

The Coalinga deposit of asbestos ore in California presents an exception to the above practices in that no primary crushing is carried out prior to ore drying. Furthermore, a wet process is employed for milling. An ore-water mixture is carried through a proprietary grinding and separating process to mill the asbestos almost entirely into fibrils. A subsequent dewatering operation produces cylindrical pellets of asbestos fibers, which measure approximately 1.0 cm (3/8 in.) in diameter and as much as 1.9 cm (3/4 in.) in length. The pellets are formed and subsequently dried without a binder. Some of the asbestos is marketed in pellet form to end users. If a completely opened form of asbestos is needed for a manufacturing process, the dry pellets can be ground either at the mill or by the end user.

Potential emission sources from asbestos milling operations include the following:

- Mine ore dumping onto wet-ore stockpiles or into receiving hoppers
- Stockpile surfaces that have become dry and are subject to wind erosion
- Belt conveying of asbestos ore, fibers, and asbestos-containing tailings
- Convey or system transfer points
- Feed and discharge ports of crushers
- Ore dryers

- Dry ore storage
- Grading screens
- Bagging of asbestos
- Tailings piles.

In the absence of controls, emissions from milling would be an estimated 2.35 million kg/yr (5.22 million lb/yr).

3.2.3 Asbestos Paper Manufacturing

Chrysotile is the predominant form of asbestos used in asbestos papermaking, but various binders and fillers may be added to produce desired properties. The process for making asbestos paper is similar to that for making wood fiber paper and board. The description below is derived from a study of the U.S. asbestos paper market.[59]

Asbestos goes into a pulper or beater and is screened and cleaned to achieve required properties. The slurry is regulated to a consistency of 1/2 to 1 percent solids, and fillers, binders, and other modifiers are added. A sheet is formed on either a Fourdrinier or cylinder machine and dewatered to approximately 20 percent by passing over suction boxes. The Fourdrinier machine uses a traveling screen for sheet formation and is suited for both high- and low-speed operations, making it preferable for production of lighter grades or for a variety of grades on a single machine. The cylinder type uses a rotating vacuum roll for sheet formation and is operated at lower speeds, making it suitable for producing heavier board grades. Solids content is increased to 35 to 40 percent by mechanical and vacuum dewatering on press rolls. Finally, the sheet is dried on dryers such as steam-heated cans or air dryers to give a solids content of 90 percent or more.

Various finishing operations may be performed at the paper-manufacturing site, or the paper may be transported and finished at other company-owned sites to reduce transportation costs. The paper product may be sold unfinished on the open market. Depending on the product, finishing steps include saturation with asphalt, tar, and resins; vinyl coating; cutting; and laminating.

Potential emission sources include storing and warehousing the bags of asbestos, opening the bags and dumping the fibers into the pulper or beater, mixing ingredients (although not likely due to the wet conditions), and slitting the finished stock. Emissions from sheet formation and subsequent dewatering are unlikely because of the wet state of the product and the presence of binders that hold the fibers in the product matrix. Finishing operations, such as saturating with asphalt and tar, are not likely to produce asbestos emissions. Little asbestos waste is created by asbestos paper production. However, when wet waste is not removed from floors or equipment, it may dry out and, if disturbed, release fibers. Emissions from uncontrolled paper manufacturing are estimated to be 24,000 kg/yr (53,300 lb/yr).

3.2.4 Asbestos Friction Materials Manufacturing

The general formulation of asbestos friction materials is:

- Asbestos: 50 to 80 percent
- Binder: 16 to 45 percent
- Friction modifiers: 5 percent.[60]

Brake linings and clutch facings may be manufactured by either a molded or woven process. The molded process is further characterized by the "dry-mix" and "wet-mix" processes. The following descriptions are from an EPA study.[61]

Manufacturing steps typically used in "dry-mix" molded brake lining manufacture begin with weighing and mixing in a two-stage mixer the bonding agents, metallic constituents, asbestos fibers, and additives. The mix is then hand-tamped into a metal mold, which is placed in a preforming press that partially cures the molded asbestos sheet. The asbestos sheet is taken from the preforming press and put in a steam-preheating mold to soften the resin in the molded sheet. The molded sheet is formed to the proper arc by a steam-heated arc former, which resets the resin. The arc-formed sheets are then cut to proper size. The lining is baked in compression molds to retain the arc shape and convert the resin to a thermoset or permanent condition; then it is finished, inspected, and packaged. Finishing steps include sanding and grinding of both sides to correct thickness, edge grinding, and drilling holes for rivets. Following drilling, the lining is vacuum-cleaned, inspected, branded, and packaged.

"Wet-mix" process is a misnomer because the molded lining ingredients are relatively dry. The designation "wet-mix" arises from solvent use in production.

After the ingredients are weighed, they are combined in a sigma blade mixer and then sent to grinding screens where the mixture's particle size is corrected. The mixture is conveyed to a hopper where it is forced into the nip of two form rollers that compress the mixture into a continuous strip of friction materials. The strip is cut into proper lengths and arc-formed on a round press bar, each operation by separate units. The linings are then placed in racks and either air dried or oven dried to remove the solvent. An alternative is to place the arc-formed linings in metal molds for oven baking. From the ovens, the linings are finished, inspected, and packaged.

Molded clutch facings are produced in a manner similar to the wet-mixed process. The rubber friction compound, solvent, and asbestos fibers are placed in a mixer churn, and the mixture is conveyed to a sheeter mill that forms a sheet or slab of the materials. The sheet is then diced by a rotary cutter into small pieces, which are placed in an extrusion machine that forms sheets of the diced material. The sheets are cut into proper size and punch-pressed into doughnut-shaped sheets; scraps are returned to the extrusion machine. The punched sheets are placed on racks and sent to a drying oven and then to a baking oven for final curing and solvent evaporation. The oven-dried sheets are sent to the finishing operations.

Woven clutch facings and brake linings are manufactured of high-strength asbestos fabric frequently reinforced with wire. The fabric is predried in an oven or by an autoclave to prepare it for impregnation with resin. The fabric can be impregnated with resin by several techniques:

- Immersion in a bath of resin
- Introducing the binder into an autoclave under pressure
- Introducing dry impregnating material into carded fiber before producing yarn
- Imparting binder into the fabric from the surface of a roll.

After the solvents are evaporated from the fabric, the fabric is made into brake linings or clutch facings. Brake linings are made by calendering or hot pressing the fabric in molds. The linings are then cut, rough-ground, placed in molds, and placed in a baking oven for final curing. Following curing, the lining is finished, inspected, and packaged.

In the manufacture of woven clutch facings, the treated fabric is cut into tape-width strips by a slitting machine. The strips are wound around a mandrel to form a roll of the fabric. The roll is pressed in a steam-heated press and then baked in an oven to cure the resin in the clutch facing. Following the curing, the clutch facing is finished, inspected, and packaged.

The friction products industry is a mature one with only marginal changes occurring in the production processes over the years; older plants are labor intensive as opposed to capital intensive.[62]

Potential sources of asbestos emissions in friction materials manufacture include the unloading and warehousing of pelletized bags, weighing, bag opening, charging of mixers, blending of ingredients, discharging of mixers, forming or rolling, curing, and finishing operations. Finishing operations generate large quantities of asbestos-containing dust.[63]

Emissions from these sources are collected using local exhaust ventilation and exhausted to fabric filters or wet collectors. Disposal or waste dust from collection devices is another potential emission source. Wastewaters from wet collectors are held in settling ponds. From these ponds, settled material occasionally is dredged, which when dry presents another potential emission source. Emissions from uncontrolled friction products manufacturing would be an estimated 2.63 million kg/yr (5.84 million lb/yr).

3.2.5 Asbestos Cement Products Manufacturing

In the United States, A/C products are made from varying amounts of asbestos, cement, and silica. On a weight basis, A/C pipe normally contains from 15 to 25 percent asbestos, 42 to 53 percent Portland cement, and 34 to 40 percent finely ground silica.[64] The A/C products may have an asbestos content range of 10 to 70 percent, but such extremes are used for specialty items only.[65] Chrysotile is the principal type of asbestos used in A/C pipe. In 1980, 83.1 percent of asbestos used in A/C pipe was chrysotile, 16.8 percent was crocidolite, and 0.1 percent was amosite (cummingtonite-grunerite asbestos).[66] Up to 6 percent of finely ground solids from damaged pipe also are used by some plants as fill material.[67] The average asbestos content of A/C pipe, by weight, has been calculated at about 18 percent. An average asbestos content of 25 percent has been reported,[68] while another report stated that asbestos content is normally below 20 percent.[69] Grades of asbestos fiber commonly used for A/C pipe are 4 and 5.[70]

Nearly all asbestos currently used in A/C sheet is chrysotile; a small amount of amosite and anthophyllite asbestos is used also. A/C sheets contain 12 to 35 percent asbestos, 45 to 54 percent cement, and 30 to 40 percent silica.[71] Grades 4, 5, and 6 commonly are used in A/C sheet.[72]

Manufacturing processes for A/C pipe and sheet may vary slightly from plant to plant, but the overall processes are the same. In general, the method used to make A/C pipe and A/C sheet is similar to methods used to make asbestos paper and asbestos millboard. Also, A/C processes can be wet, dry, molded, or extruded.

The following description of the basic process for pipe manufacture is reproduced here from an EPA document.[73]

> After thorough blending of the raw materials, the mixture is transferred to a wet mixer or beater. Underflow solids and water from the save-all are added to form a slurry containing about 97 percent water. After thorough mixing, the slurry is pumped to the cylinder vats for deposition onto one or more horizontal screen cylinders. The circumferential surface of each cylinder is a fine wire mesh screen that allows water to be removed from the underside of the slurry layer picked up by the cylinder. The resulting layer of asbestos-cement material is usually from 0.5 to 2.5 millimeters (0.02 to 0.10 inch) in thickness. The layer from each cylinder is transferred to an endless felt conveyor to build up a single mat for further processing. A vacuum box removes additional water from the mat prior to its transfer to mandrel or accumulator roll. This winds the mat into sheet or pipe stock of the desired thickness. Pressure rollers bond the mat to the stock already deposited on the mandrel or roll and remove excess water. Pipe sections are removed from the mandrel, air cured, steam cured in an autoclave, and then machined on each end.

Although the general description may apply to all A/C processes, differences often exist in methods of fiber opening, raw material mixing, and product forming. For example, raw materials usually are blended dry after fiber opening in a willow or a similar device. However, fiber opening and blending of raw materials can be achieved using wet methods.

A/C sheet is manufactured using either a dry process, a wet process, or a wet mechanical process. In the dry process, raw materials are dry mixed, and the mixture is spread evenly over a moving belt, sprayed with water, and compressed by rolls to the required thickness. The moving sheet is cut to desired sizes and shapes and is autoclaved. The dry process is generally used for shingle and siding products. Flat or corrugated sheets are produced in the wet process by introducing the A/C slurry into a mold and hydraulic press. The slurry is squeezed to remove water from the mold. The sheet is ejected from the mold and cured as in other A/C products. The wet mechanical process is similar to the process for making A/C pipe, except the A/C material on the accumulator roll is slit across the roll to produce a sheet.

Molding processes are used to make small, irregularly shaped A/C products. This process and the extrusion process are limited to specialty products.

Asbestos emission sources and their number are determined by process design. Both wet-mix and dry-mix processes share common emission sources of asbestos fiber: unloading and storage of asbestos fibers, bag opening and dumping, fiber opening, weighing, transferring, blending of raw materials, dust collection, solid waste, and wastewater disposal. Unloading asbestos involves use of forklifts to remove pallets of bags containing asbestos from railcars or trucks. Asbestos pallets are usually unitized (i.e., wrapped in plastic to help prevent damage to bags during transport). Mixing is an additional emission source in processes that use dry mixing. This emission source is absent in processes that wet mix raw materials. In addition, wet-mix processes open fibers and blend raw materials in a slurry, thus eliminating two emission sources common to dry mixing.

Disposal of asbestos fibers removed by local exhaust ventilation and filtering devices and not recirculated into the production process may be an emission source depending upon precautions taken in containing fibers during transportation and at the disposal site. Disposal of A/C solids dredged from process wastewater settling ponds is also a potential asbestos emission source.

Finishing operations also produce emissions. However, it has been reported that 90 percent of the fibers with aerodynamic diameters less than 7 μm produced by cutting, grinding, buffing, and other finishing steps differ from pure asbestos fibers.[74] In the absence of any controls, emissions from the manufacure of A/C pipe and A/C sheet would be 257,000 and 217,000 kg/yr (571,100 and 482,200 lb/yr), respectively.

3.2.6 Vinyl Asbestos Floor Tile Manufacturing

Information presented here on manufacturing V/A floor tile is from a manufacturer's product bulletin.[75]

Grade 7 chrysotile is used in the manufacture of V/A floor tile. Formulations are:

- Asbestos: 5 to 20 percent
- Binder: 15 to 20 percent
- Limestone: 53 to 73 percent
- Plasticizer: 5 percent
- Stabilizer: 2 percent.

Asbestos is received in polyethylene film bags, which can be introduced unopened into a Banbury or Baker Perkins-type mixer. The other ingredients are added at this step, and mixing proceeds at about 150° C (300° F) until a coherent mass is obtained. The hot material is transferred to a two-roll mill where the two heated, horizontal, rotating steel cylinders mix the material further and blanket it out to desired thickness, usually 2.5 to 5 cm (1 to 2 in.). Chips of contrasting colors can be added at the end of the milling operation to create a marbleized or veined pattern as the slab is processed further. The slab is passed through a series of calender rolls to bring it to the desired finished product thickness.

After leaving the calenders, the hot material is partially cooled by water spray and a wax solution is applied. Further cooling by air is necessary before dye cutting to minimize shrinkage after cutting. Embossing is done before cutting when the material is soft enough to take the pattern. Scrap and rejected tile are reworked and returned to the mixer for recovery.

Fiber receiving and storing, opening bags, dumping the fibers into the mixer, mixing, and chopping waste for recycling represent potential emission sources in V/A floor tile production. The potential for fiber release is reduced substantially once the ingredients have been worked into a hot, homogenized plastic mass. Emissions from uncontrolled V/A tile would be an estimated 25,000 kg/yr (55,500 lb/yr).

3.2.7 Asbestos-Reinforced Plastics Manufacturing

Chrysotile, primarily the Group 7 fibers, is used in the manufacture of asbestos-reinforced plastics. Although manufacture of asbestos-reinforced plastics varies, the following description, summarized from a 1976 report,[76] is common to most producers of abestos-reinforced plastics.

In the fiber-opening stage, bags of asbestos are normally opened manually, and the contents are dumped into a storage hopper and subsequently conveyed to the dry blending stage. Alternatively, asbestos may be dumped directly into the blending stage without intermediate storage or handling. During blending, dry asbestos, catalysts, and additives are mixed. From this step, the mixture is formed into a resin either by heat and extrusion or by internal shearing frictions in a Banbury mixer. The product of these "preforming" steps is a pellet, powder, or some similar "preform," which is either packaged and sold as an intermediate product or conveyed directly to a forming process.

Forming may include a variety of processes: rolling, stamping, pressing, or molding, depending on the product desired. Following this process, the product is cured, thus allowing thermosetting reactions to take place. Finally, the rough product is sent to a finishing operation, which may involve sanding, grinding, polishing, drilling, and sawing. The degree of finishing is dictated by the end-product use.

Product scrap is not recovered for reuse because of the cost of recovering the fibers once the resins have set up. Scrap is landfilled; baghouse waste may be recovered as filler.[77]

Potential emission sources include the opening and emptying of bags of asbestos; the emptied bags, which are not suitable to incorporate into the mixture; the dry blending of ingredients; and resin formation. During forming and curing, the potential for emissions, although still present, is somewhat reduced. Other potential emission sources include finishing of the cured products, waste disposal, housekeeping, and baghouse exhausts. Asbestos emissions from uncontrolled plastics production would be an estimated 162,000 kg/yr (360,000 lb/yr).

3.2.8 Asbestos Coatings and Sealants Manufacturing

Asbestos coatings and sealants usually use 10 to 12 percent asbestos. One of the two types of coatings is made from asphalt cut back with kerosene or mineral spirits, and the other is made with an asphalt emulsion and water.[78] Because of the variety of products and the number of producers, formulations are unlimited. Major components are:[79]

- Cutback products:
  - -- Cutback asphalt: 30 to 80 percent
  - -- Asbestos: 10 to 15 percent
  - -- Limestone and slate flour: 15 to 30 percent
  - -- Dispersant: 1 percent
- Emulsion products
  - -- Emulsion asphalt: 55 to 80 percent
  - -- Asbestos: 10 to 15 percent
  - -- Limestone: 5 to 15 percent
  - -- Dispersant: 1 percent.

The following is a detailed description of the process used in preparing coatings and sealants.[80]

Asbestos pallets are moved to a staging area and weighed. The bags are slit manually and dumped either into a hopper or directly into a fluffing machine. This machine breaks down the compressed fibers to an open, free condition to enable dispersion and encapsulation during asphalt mixing.

Cutting the bags and dumping the free asbestos result in fiber release. Fiber can become airborne or can fall to the floor, causing house-cleaning problems and contributing to the overall background level of asbestos exposure.

Empty bags containing residual asbestos create a disposal problem in the operation. Because several bags may be emptied at once, a waste receiver is often made available for direct disposal. Where the bags are laid on the floor or otherwise remain loose until fiber introduction is completed, free asbestos creates a housekeeping problem in the work area. Several thousand emptied asbestos bags are disposed of by a single coating manufacturer in a year's time.

Typically, fluffed asbestos fiber is transferred to hoppers or directly to a batch-mixing tank. Fiber transfer may be pneumatic, mechanical (conveyors), or manual. Pneumatic transfer systems are enclosed and use fabric filters for exhaust air; conveyors generally are enclosed. Manual transfer may be employed for small operations or for specialized, low-volume requirements.

Fluffed fiber and other dry materials are brought into contact with asphalt (and solvents, as required) in a batch tank and mixed until an even dispersion is achieved. The batch-mixing tanks normally are enclosed to prevent fiber dispersion. After a short mixing time, the asbestos fiber is bound in the asphalt. Upon completion of mixing, the asbestos is considered completely encapsulated in the asphalt with little chance for fiber dust exposure. When the batch is finished, the material is pumped to the packaging (containerizing) operation.

The predominant packaging for coatings is 19-L (5-gal) pails with sealed lids. Special orders are sometimes filled using drum containers. Bulk shipments as in tank cars are infrequent.

Asbestos emissions may occur during unloading and storage of asbestos-containing bags; bag opening and dumping fibers; bag disposal; fiber opening; manual or mechanical conveying of fluffed fibers to either hoppers or a batch-mixing tank; and final transfer of fibers into the slurry. Pneumatic conveyors or covered mechanical conveyors eliminate emission sources due to transfer of asbestos fibers.

Based on observation and theoretical calculations, it is estimated that asbestos released to the environment during manufacture of coating and paint compounds normally will be only that entrained with air emitted from bag filters.[81] It was found that no significant scrap or water effluents are produced. Dust from bag filters is the only release in which fibers are in free-fiber form. In other effluents from washing, floor spills, and wastage of the bitumastic product, asbestos fibers are encapsulated in the binder. In the absence of any controls, asbestos emissions would be an estimated 31,000 kg/yr (68,890 lb/yr).

3.2.9 Asbestos Gaskets and Packing Manufacturing

Generally, production of asbestos gaskets begins with the manual opening and dumping of bags containing asbestos into a mixing tank or a conveyor leading to the mixer. In some cases, compressed raw asbestos is dumped into a fluffer for fiber opening before the mixing step. Fillers and bonding materials also are added to the mixer and blended. Mixing may be in a dry or wet state, according to product requirements, and multiple production lines may be employed. The formulation from the mixer is calender-rolled into sheeting, which may be packaged and sold to secondary manufacturers (such as gasket cutters) for further processing. Sheeting also could be sold to distributors serving the maintenance market.

Asbestos-based packing can be manufactured by a number of processes, the most common being impregnation of dry yarn with lubricants that coat the fibers. These yarns are braided into a continuous length of packing and then are calendered to specific sizes and cross-sectional shapes. The sized braid may be coiled, boxed, and sold to the maintenance trade, or it may be cut and die-formed to the manufacturer's specifications. A variation of braided packing can be produced by first extruding a mixture of asbestos fiber, binder, and lubricants, and then braiding lubricated asbestos yarns over the extrusion.

The primary potential emission sources are bag opening, dumping of asbestos, and the mixing step. Receiving and warehousing of raw fibers, disposal of emptied bags and product scrap, and braiding and twisting of treated asbestos yarn also can be considered potential emission sources. Asbestos emissions from the uncontolled manufacture of asbestos gaskets and packing would be an estimated 12,000 kg/yr (26,670 lb/yr).

3.2.10 <u>Asbestos Textile Manufacturing</u>

Asbestos textiles are manufactured from chrysotile asbestos, primarily of the long, Group 3 fibers. The product is typically composed of 75 to 100 percent asbestos, and organic fibers comprise 0 to 25 percent of the product.[82] Textiles also may be reinforced with wire or synthetic yarns, depending upon end use.

A majority of asbestos textile production is by conventional process, while 5 to 10 percent of U.S. asbestos textile production is by wet extrusion. The conventional process can be subdivided into dry-woven and damp processes, the difference being the application of moisture to the yarn by contact with a wet roller or a mist spray. Unless noted otherwise, the following descriptions of conventional and wet processes were adapted from Daly.[83]

In the conventional process, raw asbestos and other ingredients are weighed and dumped into several blending machines that operate continuously to mix the formulation components gently. Mixing takes place as the asbestos slowly moves toward the rear of the machine, is drawn up an incline, and tumbles to the bottom. Part of the mix is carried over the incline and falls into a hopper. The rear of the blending machine is enclosed and hooded to minimize fiber evolution. As the hoppers are filled with the blended fibers, the fibers are transferred to the carding machines or may be conveyed pneumatically to the carding machines.

The carding operation combs the fiber mix into a parallel (oriented) fiber mat, which is pressed mechanically and layered into a lap. At the finishing card, the lap is separated into thin, continuous strips of fiber known as roving. At this point, cotton, rayon, or other materials may be added to the roving to impart strength and other characteristics. The lap, matting, or roving may be packaged and sold to secondary industries. Otherwise, the roving proceeds to the spinning operations.

The roving is spun and then twisted to add strength. In the damp process, the roving is moistened via wet rollers before spinning. This dampening process is employed to reduce fibrous dust during subsequent processing. In some cases, for better product quality, the roving is not wetted.

Spun roving, known as single yarn, can be twisted with other single yarn or other material to produce plied yarns or twines. Plied yarns can be coated to produce thread or treated yarns, or woven to produce tapes, cloth, or woven tubing. It also can be braided to produce cord, rope, or braided tubing. Spun yarn can be processed without twisting to produce woven, braided, and otherwise treated products.

At the weaving operations, the yarn is first put on a beam or creel, which handles a large number of strands to feed a loom. A damp or dry loom can be used to create cloths of different characteristics.

The wet process differs from the conventional processes in that raw asbestos is dumped directly into a slurrying tank with water and chemicals. The resulting slurry is extruded directly into strands. These strands proceed to the spinning and subsequent operations similar to conventional processing. The wet process thus avoids the blending and carding operations, which generate substantial amounts of asbestos dust in the conventional process. Wet-processed textiles possess different characteristics than do conventionally woven products; therefore, secondary manufacturers must adapt production techniques to compensate for altered processability and final-product characteristics.

Fiber release may occur during asbestos receiving and storage as a result of damaged bags. In the conventional textile process, the greatest potential for fiber release generally is associated with bag opening and dumping (commonly done manually), blending, transporting blended fibers, and carding. The high-speed working of yarn in spinning, twisting, and weaving also will release asbestos fibers. Inspection and shipping areas also may be considered potential emission sources; however, potential is normally low at this stage of the process.

In the wet process, the potential for fiber release is greatly decreased because blending and carding operations have been eliminated. However, bag opening and dumping may release asbestos fibers. Spinning, twisting, weaving, and braiding in the wet processes release fewer fibers than do the same operations in the conventional process.[84] Asbestos emissions from uncontrolled textile manufacturing would be an estimated 19,000 kg/yr (42,200 lb/yr).

3.2.11 Chlorine Manufacturing

A special grade of asbestos is used as a diaphragm in the percolating diaphragm method of chlorine production via brine electrolysis. In the electrolytic process, cathode surfaces generally are lined with a layer of asbestos, either in the form of paper or as vacuum-deposited fibers. The asbestos diaphragm maintains the caustic strength and minimizes the diffusional migration of hydroxyl ions. All diaphragms gradually clog with residual impurities not removed from the brine and with graphite particles that break from the anode. The diaphragms therefore are renewed at regular intervals, some lasting as long as 6 to 15 months. Depending on the number of cells per plant, only a few cells are renewed each week; 1 plant with 86 operating cells renewed an average of 3 cells per week.[85] Asbestos paper sheets were used extensively in diaphragm cells through the 1930s and 1940s but have been replaced by almost all commercial diaphragm cells with an asbestos slurry.[86]

The slurry, made by mixing approximately 59 kg (130 lb) of asbestos fibers with water, is vacuum-deposited through a perforated plate onto the cathode pole. HAPP (Hooker asbestos plus polymer) diaphragms are basically the same but contain a fluoropolymer resin to help diaphragm bonding while reducing voltage load. Use of paper sheets as diaphragms has diminished because the voltage load is significantly higher for paper, as opposed to the vacuum-deposited diaphragm. A long-fiber, high-quality paper is still being produced and is available to customers who operate aged electrolytic equipment as well as the newer processes. It has been suggested that the asbestos paper can be blended with water to form a slurry and vacuum-deposited onto the cathode, thereby eliminating the potential hazard associated with handling bags of asbestos fibers.[87]

The potential for asbestos emissions is greatest for bag opening, dumping into the mixer, cell removal, and waste disposal. Data were not available to estimate asbestos emissions from the production of chlorine.

3.2.12 Shotgun Shell Manufacturing

Asbestos is mixed with wood flour and wax and pressed into base wads.[88] The mixture's formulation, by weight, is:[89]

- Asbestos: 36 percent
- Wood flour: 54 percent
- Wax: 10 percent.

Emission sources likely in the manufacture of asbestos-containing shotgun shells include receiving and warehousing of asbestos, opening and dumping of asbestos, mixing, wad pressing, and subsequent handling and processing. Baghouse operations, including exhausts, are sources of fiber release into the environment.[90] Data were not available for estimating emissions.

3.2.13 Asphalt Concrete Batching

In the manufacturing process, bags of asbestos are opened manually and dumped into a conveyor system or are introduced opened into the mixer. The asbestos is mixed first with dried aggregate, after which hot liquid asphalt is added to the asbestos-containing aggregate and thoroughly mixed.[91]

Emissions can occur during manual bag opening, emptying of asbestos into the conveyor hopper, and dry mixing. Empty bags, if not incorporated into the mixture or properly contained, can be points of fiber release. Considering that only negligible amounts of asbestos currently are used, emissions are probably small. Data were not available for estimating emissions from asphalt concrete plants.

3.2.14 Asbestos Product Fabrication

In general, operations involved in secondary fabrication are similar to finishing operations of the primary manufacturing segments. They may use such operations as grinding, sawing, sanding, punching, pressing, or slitting, depending on the fabricated product desired.

Secondary fabricators receive their asbestos products from the primary industry in a bound form and do not have the problem of handling raw asbestos fibers.[92] Some asbestos-containing dust may be released during the receiving of these products due to residual dust on the product or through breakage or abrasion during transport.[93] The important emission sources include fabrication operations, such as grinding, drilling, sanding, sawing, routing, cutting, slitting, and others that destroy the integrity of the product.[94] For those fabrication sources covered by the current NESHAP (cement building products, friction product fabrication, and certain cement or silicate boards), emissions in the absence of controls would be an estimated 304,000 kg/yr (675,560 lb/yr).

3.2.15 Construction Industry

The construction industry consumes approximately 75 to 80 percent of all asbestos products. Except for A/C sheet, flooring felts, and textiles shared by secondary industries, these products are sold directly to construction contractors either by the manufacturers or through distributors. Products are used in the following construction types:

- Private single-unit residences
- Private multiunit residences and nonhousekeeping units
- Residential additions and alterations
- Private nonresidential buildings
- Educational and religious facilities
- Hospitals and institutions
- Farm nonresidential buildings
- Telephone and telegraph facilities
- Water facilities
- Sewer works
- Electric and other public utilities
- Public housing
- Miscellaneous public construction, including military facilities.

In addition to erection and installation activities, maintenance and repair activities may require removal of asbestos products. Demolition activities may also involve removal or destruction of asbestos-containing materials.

Construction contractors have been called on to encapsulate sprayed-on asbestos materials in lieu of removing friable asbestos materials from public buildings. Although this activity neither uses nor removes asbestos materials, it involves potential asbestos emissions. The number and types of contractors called on to perform this activity are not known, partially because measures to correct asbestos fiber fallout in public buildings have not yet been addressed by Federal and State Governments.

The process or operational descriptions for construction, renovation, and demolition activities are described in the following paragraphs.

Although A/C pipes are manufactured in standard sizes and in half and quarter lengths with proper couplings, pipes occasionally must be cut to length and machined to fit coupings. Pipes that are machined all over by the manufacturer do not require additional machining. Either special tools designed for cutting and machining pipe or a standard power saw equipped with an abrasive or diamond wheel is used.

An economic analysis of the occupational standard estimated that 1976 production was 27 million m (90 million linear ft) of pipe, that the installation production rate was 67 m (223 ft) per day for a typical crew of three or four people, and that one 15-min cutting-machining operation is required for each 390 m (1,300 ft) of pipe. It was estimated that 9,230 cuts per year would be made in the field on A/C pipe.[95]

Field cutting of A/C sheets may be required at corners and around wall apertures. Holes must be drilled on A/C sheets for attachment purposes. Circular saws equipped with either an abrasive wheel or a diamond- or carbide-tipped blade are used for cutting, and standard portable drills are used for the holes. The same economic analysis showed that of the 8.6 million m^2 (96 million ft^2) of A/C sheet produced in 1976, 75 percent was consumed by the construction industries. It was estimated that field fabrication was required on 5 to 30 percent of the installed sheet and that each sheet averaged 2.88 square meters (32 square feet). Therefore, of approximately 2 million sheets consumed by construction, only 100,000 to 600,000 sheets require field cutting per year.

The average amount of A/C sheet used per project was reported as 2,227.5 m^2 (24,750 ft^2). The 1976 production figure for A/C sheet was used to determine that 2,909 projects using A/C sheet were undertaken that year.

If, for each site, field fabrication is required on 5 to 30 percent of the sheets, approximately 38 to 230 sheets need field finishing.

Most A/C panels are ordered to specifications from the manufacturer, minimizing the need for field fabrication. However, because the panels are attached to frames with screws, drilling is necessary. Standard electric drills are used for this purpose. Occasionally, cutting is required, which is performed by using a portable circular saw equipped with an abrasive or diamond cutting wheel.

The 1976 figures showed that 0.3 million m^2 (3 million ft^2) of A/C panel was produced and that the daily installation rate was approximately 44.6 m^2 (495 ft^2) for an average crew of four people.[96] Economic analysis of the occupational standard showed that approximately 753 m^2 (8,365 ft^2) of panel was needed per project and that 350 projects used A/C panels in 1976. Analysis also showed that for every 1,115 m^2 (12,000 ft^2), approximately 32 cuts taking 15 min each were required and that approximately 6,500 holes had to be drilled. Therefore, for each site 22 cuts and 4,500 holes were necessary (assuming a constant market demand).

The economic analysis of the occupational standard indicated that asbestos felts coated with asphalt are cut with a knife or shears at the installation site. Then the felts are placed over the roof deck in layers and roofing tar is mopped on between the layers.[97] In another economic analysis, it was reported that three plies are layered for built-up roofing.[98] Two types of roofing installations have been described.[99] One type of built-up roofing is applied by layering uncoated asbestos roofing felts, and the second involves layering previously coated felts and using cold adhesives to cement the plies together. In addition to their use in built-up roofing, asbestos felts are often used as an underlayment for other roofing materials such as asphalt shingles.

Approximately 321 km^2 (200 mi^2) of commercial built-up roofing is installed annually, and the daily installation rate for a seven-man crew is about 216 m^2 (2,400 ft^2).[100] The number of cuts and the time required for each installation depend upon the size of the roof and the desired size of each ply.

The quantity of annually installed roofing reported in 1976 by the National Roofing Contractors Association (NRCA) may have changed radically, as indicated by current production numbers.[101] The 1979 production of roofing felts was 125,640 Mg (138,500 tons).[102] Because roofing felts usually are manufactured in weights of 4.3 to 6.8 kg/9 m^2 (9-1/2 to 15 lb/100 ft^2),[103] based on an average, the felt installed in built-up roofs could not have exceeded 171.6 km (66 mi^2). Because roofing felts are not used solely for built-up roofing, the amount may still be less.

Asbestos textile insulation materials such as cloth and rope lagging usually are used for electrical insulation and require pulling the cloth or rope from rolls or coils and cutting it to desired lengths. The cloth and rope are usually cut with mechanical cutters, knives, clickers, dies, or scissors. Cloth can be torn from the roll, but this is not recommended. Materials are fitted, hammered and nailed, glued, and sewn during application.

Thermal insulation usually consists of paper and millboard, but cloth or woven tape may be used. Installing paper and millboard sheets for thermal insulation requires field fabrication to fit the materials onto equipment and structures. Paper and millboard sheets must be cut to shape and length. For piping, flues, and circular stacks, paper, millboard, cloth, or tape is wrapped around the objects in layers and can be fixed to the surface with wire, bands, or sheathing. Fabric covering can also be applied with or without coating or paints. For furnaces, boilers, turbines, reactors, kettles, or other heated vessels, the asbestos millboard is attached to the surfaces by studs, bolts, bands, expanded mesh, or sheet metal.[104] Data are not available to estimate asbestos emissions from construction although emissions are considered insignificant as a result of current use characteristics.

3.2.16 Renovation

Removal of friable asbestos-containing insulation is regulated by the asbestos NESHAP. In addition to dislodging material from ceilings, walls, pipes, ducts, or other surfaces with scrapers, picks, drills, saws, or other hand-held or powered tools, removal operations typically include containment of the area, sufficient wetting of the asbestos material prior to stripping, and capture of emissions at the source by local exhaust ventilation.

Sprayed-on asbestos materials were commonly used by the construction industry from 1946 to 1973.[105] In 1950, more than half of all multistory buildings constructed in the United States used some form of sprayed-on fireproofing, and in 1968, 37,000 Mg (40,000 tons) of fireproofing was sprayed on or in U.S. buildings.[106] In 1970, 37,000 Mg (40,000 tons) of fireproofing was used again for the same purpose.[107] These sprayed-on materials containing asbestos were used for fireproofing, thermal and acoustical insulation, decoration, and condensation control. Fireproofing accounted for the largest amounts on structural steel components of multistory buildings. Thermal insulation was applied on turbines and in reaction vessels in chemical plants and refineries, boiler breechings, and stacks. Sprayed-on materials containing asbestos were applied for decorative ceilings and for noise absorption in large public buildings and restaurants. Walls and ceilings of indoor swimming pools, laundries, textile plants, and other industrial buildings where condensation might have caused corrosive damage were sprayed with asbestos-containing materials.[108] The EPA has estimated that approximately 8,600 public schools contain friable asbestos materials. Asbestos has been used as thermal insulation on boilers and pipes since the early 1900s.

Encapsulating with sealants has replaced removal of sprayed asbestos materials from some buildings. However, the current trend is removal rather than encapsulation. Sealing of sprayed asbestos surfaces involves applying material that will envelop or coat the fiber matrix and eliminate fallout and protect against contact damage while minimizing fire hazards. Sealants are applied over the surface of the material using airless spray equipment at low-pressure settings.

Approximately 260 km^2 (100 mi^2) of commercial and industrial roofing is repaired or renovated annually requiring removal of roofing felts containing asbestos. With a crew of five people, the average daily removal rate is 149 m^2 (1,600 ft^2) of old roofing.[109] Ninety-nine percent of removal is performed by manually pulling roofing from the deck. When insulation is attached, the roofing is usually cut into 0.6- by 0.6-m (2- by 2-ft) squares, which are thrown manually to the ground.[110]

Asbestos associated with drywall removal is contained in spackling, taping, and joint compounds. Although use of asbestos-containing patching and joint compounds was banned in 1977, prior construction used such compounds. Therefore, it is likely that of 148.5 million m^2 (1.7 billion ft^2) of drywall removed each year, some--the footage installed prior to 1977--may produce free-form asbestos fiber emissions when removed.[111]

Drywall usually is pulled manually from the frame; however, tools such as axes or hammers may be required initially to break into the wall.[112] The wall joints are cut and, if the drywall had been nailed to wood studs, the nails are punched through to salvage the material. If the drywall had been screwed onto metal, the screws are removed and the joint tape is cut.

A common practice among floor tile installers was sanding old floor tile with conventional belt sanders before resurfacing. However, in their instruction manuals, manufacturers warn against sanding old tile, a practice most contractors have discontinued.[113] The number of installations where sanding is continued is not known.

Like drywall, asbestos blanket (cloth), rope, and asbestos paper and millboard insulation on turbines, boilers, pipes, and ducts is manually torn off surfaces or from cavities. Approximately every 3 to 5 years large amounts of insulation are removed as a result of inspections and repairs required on turbines in electric power-generating plants.[114]

Asbestos emissions from uncontrolled renovation would be an estimated 1,600 kg/yr (9.5×10^{-4} kg/m^3 x 1,718,000), or 3,560 lb/yr.

3.2.17 Demolition

Demolition is the wrecking or taking out of any load-supporting structural member and related activities. Demolition of structures is performed for various reasons, including site preparation for new construction, removal of unsafe or nuisance structures, and salvage of materials for resale. The methods of demolition typically used are wrecking by ball and clam, floor-by-floor dismantling, implosion, and pushing or pulling down by backhoe or bulldozer. Before a structure is atually torn down by one of these methods, other related demolition activities may take place such as ripping out walls, ceilings, and pipes. Demolition, including related demolition activities of asbestos-containing structures, may produce asbestos emissions if the asbestos were not removed first. Friable asbestos materials may be found as insulation, fireproofing, or decorative covering on pipes, ducts, boilers, furnaces, turbines, load-supporting structures, ceilings, and walls. Stripping and removal of asbestos materials may involve cutting, scraping, chipping, and other dust-producing activities. In addition, asbestos emissions can result from falling debris as the asbestos is stripped and during any handling of asbestos materials prior to containment or disposal as waste.

In the absence of controls, asbestos emissions from demolition would be about 170 kg/yr (9.5×10^{-4} kg/m^3 x 174,000 m^3), or 378 lb/yr.

3.2.18 Asbestos Waste Disposal

When manufacturing waste is transported to off-site landfills, it is generally in sealed or covered containers. In some cases, the waste site operator may dig a trench to bury the waste immediately, and in other cases the asbestos waste containers are deposited with other waste and covered at the end of the workday. When manufacturing waste is transported to an on-site landfill, it may be in sealed containers, in the form of a slurry, or, for product scrap, in loose form. The waste may be covered daily, or it may be kept wet and covered at less frequent intervals.

Renovation waste may be handled in a manner similar to manufacturing waste if the renovation involved only activities such as stripping friable asbestos materials from equipment or structures. In other cases, renovation waste as well as demolition waste may be transported to the landfill attached to equipment, pipes, or structural members that are removed during the renovation or demolition operation. In the latter case, asbestos material is normally wetted before transport. When the loose material is delivered to the landfill, it is dumped along with other demolition debris and covered at the end of the workday.

Some asbestos waste, especially baghouse fines, may undergo processing into nonfriable forms, which are then ready for disposal. Pelletizing is an example of such a process and involves the addition of water or water and cement to asbestos-containing dusts from baghouses and then rotating the mixture in a drum to form small, nonfriable pellets. This can be an emission source.

In the absence of any controls, asbestos emissions from demolition and renovation waste disposal would be about 4,200 and 41,800 kg/yr, respectively (9,330 and 92,890 lb/yr, respectively).

3.2.19 Asbestos Drilling Muds

Asbestos may be added to drilling muds at the drill site or at a central mixing plant. At the drill site, asbestos is manually dumped from a bag into a cone hopper from which it enters the drilling mud and is mixed. Potential sources of emission are the dumping operation and the handling of empty bags. Area and personal sampling conducted at a number of drill sites yielded asbestos concentrations well below the OSHA standards.[115] These results indicate that emissions to the atmosphere are quite small. When central mixing plants add asbestos to drilling muds, bags of asbestos are emptied into a hopper that is maintained under negative pressure by the flow of drilling mud in an adjacent pipe. Potential emission sources include the dumping operation and the handling of empty bags.

Disposal of spent drilling muds may, in some cases, constitute a potential emission source. When well drilling operations cease, drilling muds may be pumped into a truck and hauled to another drill site or back to a central mixing plant for reprocessing. Alternatively, drilling muds may be disposed of on-site. On-site disposal is usually accomplished by pumping the mud to a settling pond. The water may be allowed to evaporate or it may be treated and purified after the solids have settled out. Solids that remain in the pond may eventually be covered with earth.

3.2.20 Removal and Recycling of Asbestos Pavement

Asphalt pavement topping containing asbestos fibers was laid in the 1960s and 1970s. After its useful life, the pavement may be covered with more layers of paving, milled to provide a smooth surface for extended life, or broken up and discarded to make way for new paving. When milled, the process uses a wet milling machine followed by a sweeper. The wet debris is collected and recycled or disposed of in a licensed landfill. For removal, the pavement is wet-sawed such that large chunks can be broken out with a backhoe. The debris is either recycled or discarded in a licensed landfill.

Emissions from removing the pavement would occur during operations that are performed to saw and break up the material into slabs for removal. However, the sawing operations are generally performed with wet saws, and debris from the removal process is disposed of in municipal landfills. It is unlikely that significant emissions exist from the removal process. Milling is also performed with water-cooled equipment, and it is unlikely that significant emissions exist from the removal process. Potential sources of emissions from recycling include loading, unloading, and conveyor operations, as well as grinding and sizing. Hoods and dust collectors (scrubbers and baghouses) are generally used for these recycling operations. Mixing is not considered an emission source because the hot asphalt coats the asbestos and inhibits emissions.

3.3 REGULATORY BASELINE

Federal regulations governing asbestos have been established by the EPA under four environmental statutes: the Clean Air Act (CAA), the Toxic Substances Control Act (TSCA), the Asbestos Hazard and Emergency Response Act (AHERA), and the Resource Recovery and Conservation Act (RCRA). These regulations are summarized in Section 3.3.1. Other major Federal regulations are implemented by the Occupational Safety and Health Administration (OSHA) and the U.S. Department of Transportation (DOT). These regulations are described in Section 3.3.2. In addition, many States have general or asbestos-specific regulations that supplement or are more stringent than current Federal regulations. A summary of the regulatory analysis conducted to determine which States and regulations already require the regulatory alternatives under consideration is included in Section 3.3.3. The full regulatory analysis is included in Appendix E.

3.3.1. EPA Regulations

3.3.1.1 CAA Regulations. The current NESHAP (40 CFR 61, Subpart M) requires asbestos mills, 11 types of manufacturing operations, and 3 types of fabricating operations to either discharge no visible emissions or meet equipment specifications for air cleaning equipment (i.e., baghouses). Owners or operators of these facilities must monitor and inspect control devices, maintain records of the results, and submit quarterly reports to EPA if visible emissions occur. High-efficiency particulate air (HEPA) filters or wet collectors can be used as alternatives to fabric filter systems.

For all demolition and for renovation operations involving more than 78 m (260 ft, linear) of asbestos on pipes, or 14.4 m^2 (160 ft^2) of asbestos on other facility components, the NESHAP requires a 10-day advance notification to EPA. Work practices involving the the wetting, removal, and handling of friable asbestos (overseen by a trained supervisor) are required for jobs meeting this threshold level. Wetting is not required during freezing weather (although temperature readings must be made and recorded) or if, during a renovation, wetting would unavoidably damage equipment. In the latter case, local exhaust ventilation equipment must be used. The work practice and equipment control requirements do not apply to demolition and renovation operations under the size threshold.

No visible emissions are allowed during the collection, processing, packaging, transporting, or deposition of asbestos waste. Alternatively, dust and tailings from mills can be mixed with a wetting agent, and asbestos waste from other types of facilities can be mixed with water (a slurry is required for control device waste) and sealed in leak-tight containers or processed into nonfriable pellets or other forms. No visible emissions are allowed from mixing, wetting, and pelletizing operations, or air cleaning methods must be used. Provisions also are included in the NESHAP for container labeling, marking of transport vehicles, and waste shipment records and reports.

At active disposal sites, the landfill operator must inspect waste shipments and maintain disposal records. At inactive sites, the presence and location of the asbestos waste must be recorded on the property deed. The operator also must notify EPA before disturbing any area where asbestos has been buried. The owner or operator of an active or inactive site must meet a no visible emissions limit, use dust suppression agents, or comply with cover requirements (i.e., 15.2 cm [6 in.]) of compacted nonasbestos material at the end of each operating day or at least once every 24 hours at active sites; 15 cm [6 in.] of compacted nonasbestos material and a vegetated cover or 60 cm [2 ft] of compacted nonasbestos material at inactive sites). Warning signs and fences also are required at active and inactive disposal sites.

The NESHAP also requires that material spray-applied on buildings, structures, pipes, and conduits contain no more than 1 percent asbestos. No visible emissions are allowed from spraying equipment and machinery, or air cleaning requirements must be met. A 20-day advance notification also is required. The NESHAP also prohibits the installation or reinstallation of insulating materials containing commercial asbestos if the materials are molded and friable or wet-applied and friable after drying, except for spray-applied insulating materials meeting the spraying requirements.

3.3.1.2 <u>TSCA Ban and Phasedown Rule</u>. The TSCA ban and phasedown rule (40 CFR 763, Subpart I) prohibits the manufacture, importation, and processing of the following asbestos products by August 27, 1990: flooring felt, roofing felt, pipeline wrap, asbestos cement (A/C) flat sheet, A/C corrugated sheet, vinyl asbestos (V/A) floor tile, and asbestos clothing. These products cannot be distributed in commerce after August 25, 1992.

Prohibited by August 25, 1993 are beater-add gaskets (except specialty industrial gaskets), sheet gaskets (except specialty industrial gaskets), clutch facings, automatic transmission components, commercial and industrial friction products, drum brake linings (original equipment), and disc brake pads for light and medium weight vehicles. These products cannot be distributed in commerce after August 25, 1994. By August 26, 1996, the following products are banned: A/C pipe, commercial paper, corrugated paper, rollboard, millboard, A/C shingle, specialty paper, roof coatings, nonroof coatings, brake blocks, drum brake linings (aftermarket), disc brake pads for light and medium weight vehicles (aftermarket), and disc brake pads for heavy weight vehicles (aftermarket). These products cannot be distributed in commerce after August 25, 1997.

Products subject to the rule must be labeled. Exemptions can be made for products if the applicant can prove that the activity will not result in unreasonable risk and that the applicant has made good faith efforts to develop substitutes. Asbestos containing products for military uses will be exempt.

3.3.1.3 AHERA School Rules. The AHERA school inspection rule (40 CFR 763, Subpart E) requires all local education agencies to identify asbestos containing materials in school buildings and take appropriate actions to control releases. An accredited inspector must inspect for all friable and nonfriable asbestos, reinspect at least every 3 years, develop a management program, and design or conduct major actions to control asbestos.

An operation and maintenance (O & M) program also must be developed for any building with friable asbestos. O & M staff can perform asbestos abatements involving 3 0.3 m^2 (3 ft^2, linear) or less but must receive training. For larger amounts, accredited personnel must perform the work. Any one or combination of the following can be used for O & M jobs: (1) wet methods, (2) removal methods (glove bags, removal of entire pipe or structure, minienclosure), (3) enclosure of materials, or (4) maintenance programs. Vacuums with HEPA filters are required for use in evacuating glove bags and for cleanup activities. The rules also include provisions for worker protection and waste disposal.

Clearance air monitoring is required to determine completion of the response action. The area is approved for reoccupancy when the average concentration of fibers for each of the five samples collected in the affected area is not statistically different (as determined by a Z-test calculation) from the average of the five samples taken outside the work space and the average of the three field blanks. Transmission electron microscopy (TEM) is used as the analytical method.

3.3.1.4 RCRA Regulations and Solid Waste Disposal Guidelines. Existing guidelines established by EPA for the land disposal of solid wastes are included in 40 CFR 241. The guidelines recommend a daily compacted cover of at least 15.2 cm (6 in.) with an intermediate cover of at least 30 cm (1 ft) for areas where additional cells are not to be constructed for extended periods of time (1 week to 1 year). A final cover of at least 60 cm (2 ft) should be applied on each area as it is completed or if the area is to remain idle for more than 1 year. The existing guidelines do not contain provisions specific to asbestos.

The EPA also has established criteria for the classification of solid waste disposal facilities and practices (40 CFR 257). These rules set general performance standards that address floodplains, endangered species, surface and ground water, land application, disease, air, and safety. The standards are applicable to all solid waste disposal facilities (and wastes) regulated under RCRA Subtitle D. Under the existing standards, open burning of residential, commercial, institutional, or industrial solid waste is prohibited. Periodic application of cover material or other appropriate techniques are required to protect the public health from disease vectors. Uncontrolled public access also is prohibited.

The EPA has proposed to amend 40 CFR 257 and to add new provisions specific to municipal landfills in 40 CFR 258 (53 FR 33314, August 30, 1988). The proposed revisions to 40 CFR 257 include information requirements to aid in developing data on industrial solid waste disposal facilities and construction/demolition landfills in the future. The new Part 258 would apply to all new and existing municipal solid waste landfills except for closed facilities. The proposed rules also establish minimum criteria for location, design, operation, cleanup, and closure. Open burning would be prohibited, and existing requirements for controlled access would be expanded. The criteria would require application of a suitable cover at the end of each operating day (or at more frequent intervals); at least 15.2 cm (6 in.) of daily cover is recommended. Run-on controls (e.g., diversion structures) and runoff controls (trenches, berms, dikes) also would be required. The proposed rule also would require training of workers to recognize hazardous waste or illegal dumping. A closure plan and postclosure care, including maintenance of final cover, periodic cap replacement, and monitoring, would be required for 30 years. As proposed, the revised criteria do not contain any asbestos-specific provisions.

3.3.2 Other Federal Regulations

3.3.2.1 OSHA Regulations. The OSHA workplace standard (29 CFR 1910.1001) applies to all workplaces covered by OSHA, including ship repairing, ship building, shipbreaking, and longshoring/marine terminals. Similar standards for the construction industry (covering demolition or salvage; removal or encapsulation; alternation, repair, maintenance, or renovation; product installation; spill/emergency cleanups; and transportation, disposal, storage, and containment of waste) are contained in 29 CFR 1926.58.

The current OSHA standards for workplaces and the construction industry establish an 8-hour time-weighted average (TWA) permissible exposure limit of 0.2 fibers per cubic centimeter (f/cm^3) of air for asbestiform minerals. An excursion limit of 1 f/cm^3 (30-min TWA) also is included, together with an action level of 0.1 f/cm^3 (8-hr TWA) that triggers initial employee monitoring and other requirements. Exposure to nonasbestiform minerals is limited to 2 fibers longer than 5 $\mu m/cm^3$ of air (8-hr TWA) under the current standards. Provisions also are included in the standards for the use of regulated areas, medical surveillance, exposure monitoring, training, protective clothing and hygiene facilities, waste handling, warning labels, respirators, and recordkeeping.

For the workplace standard, engineering controls and work practices are required except to the extent that they are not feasible. If the controls and work practices are not sufficient to reduce exposure to the established limits, the employer must use them to reduce exposures to the lowest levels achievable and supplement the controls and work practices with respirators. Depending on the type of process, feasible engineering controls and work practices generally include local exhaust ventilation (LEV) for conveyors and work stations; careful handling of bags and bag repair in receiving departments; automatic or manual bag opening where bags are opened before mixing; closed blending tanks with LEV for dry mixing;

improved housekeeping; and shrouded tools. Provisions also are included for the handling of asbestos fiber and related materials (e.g., asbestos-cement) and for waste handling.

Methods of compliance for the construction standard may include any one or combination of the following: (1) LEV equipped with HEPA filter; (2) general ventilation systems; (3) vacuum cleaners equipped with HEPA filters; (4) enclosure or isolation of process; (5) wetting methods, wetting agents, or removal encapsulants; (6) prompt disposal in leak-tight containers; or (7) other feasible work practices or engineering controls. Whenever these methods are not sufficient to achieve the limits, the rule requires the supplemental use of respirators.

The construction standard requires the use, wherever feasible, of negative pressure enclosures for removal, demolition, and renovation operations. The nonmandatory guidelines in Appendix F of the OSHA standard described the exhaust air filtration system for the negative pressure enclosure as being equipped with a HEPA filter. Small-scale, short duration jobs are exempt from the enclosure requirement. Although not defined, examples of "small-scale, short duration" operations include pipe repair, valve replacement, installing or removing drywall, roofing, and other general building maintenance or renovation. Nonmandatory guidelines in Appendix G of the OSHA standard recommend the use of glove bags, removal of the entire pipe or structure, or minienclosures for these jobs.

On July 20, 1990 (55 FR 29713), OSHA proposed to lower the permissible exposure limit from 0.2 f/cm^3 to 0.1 f/cm^3 for all employees subject to the workplace and construction standards. The proposed rule also would add and clarify provisions for methods of compliance with both standards.

The construction standard also would be revised to require a negative pressure enclosure unless specifically exempted. The guidelines in Appendix F of the OSHA construction standard, which require HEPA filters, would be mandatory. Exemptions would include small-scale, short duration operations; operations where the erection of enclosures are infeasible; and roofing removal jobs. "Small-scale, short duration operations" would be specifically defined, and compliance with OSHA's Appendix G guidelines would be mandatory. The proposed rule also would require additional communication of asbestos hazards among building owners, employers, and employees; recordkeeping by building owners; and supervision of construction operations by trained personnel.

The proposed revisions to the construction standard would require that cleaning of floors and surfaces on which asbestos dust can accumulate be performed at least once per shift in primary and secondary manufacturing sectors. Wet methods would also be used for cleanup, in addition to HEPA-filtered vacuums. The use of high-speed sanders for sanding (buffing) of asbestos floor tiles would be prohibited; only low abrasion pads used at speeds lower than 190 rpm would be allowed.

3.3.2.2 DOT Rules. The DOT rules (49 CFR 171, 172, 173, and 174) prohibit the transportation of hazardous materials and wastes in commerce unless the materials are properly classed, described, packaged, marked, labeled, and are in condition for shipment according to applicable regulations (40 CFR 171). Under DOT regulations (40 CFR 172), asbestos is classified as an "other regulated material" (ORM-C) and is exempt from rules governing hazardous waste transportation with the exception of labeling requirements. However, in the event of a spill during transportation, the reportable quantity under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) is 0.45 kg (1 lb).

The DOT rules for shipments and packaging (49 CFR 173) apply only to the transportation of commercial asbestos. Asbestos that is fixed in a natural or artificial binder material (e.g., cement, plastic, asphalt, resins, or mineral ore) is excluded, as are manufactured products containing asbestos or any materials or products whose commercial value is not dependent on the asbestos content. Commercial asbestos must be transported in bags or other nonrigid packaging in closed freight containers, motor vehicles, or railcars loaded by and for the exclusive use of the consignor and unloaded by the consignee. The bags or nonrigid packaging must be dust- and shift-proof or strong and shift-proof in strong external fiberboard or wooden boxes. Shipping papers are required, but not a hazardous waste manifest. When transported by rail, asbestos must be loaded, handled, and unloaded, and any asbestos contamination of the railcar removed in a manner that will minimize occupational exposure to airborne asbestos particles released during transportation (40 CFR 174).

3.3.3 State Regulations

An analysis was performed to compare the provisions of State rules to the Federal rules described above to determine which States already required provisions similar to or equivalent to the regulatory alternatives under consideration. Regulations were analyzed for 50 States and the District of Columbia; for the purpose of this analysis, the District of Columbia is counted as and referred to as a State. Many States now have standards that exceed the current NESHAP and other Federal regulations governing asbestos, particularly for demolition/renovation operations and waste disposal.[116] A tabular compilation of the analysis is included in Appendix E; the results are summarized below.

3.3.3.1 Milling, Manufacturing, and Fabricating. Few, if any, States were identified that exceed Federal standards for milling, manufacturing, and fabricating operations. No States were identified that specifically require HEPA filters on the exhaust streams of air cleaning equipment. However, Colorado requires compliance with the no visible emission standards and equipment specifications and Illinois requires no visible emissions and limits concentrations to 2 f/cm^3 or less. No State regulations were identified that included malfunction provisions or that addressed the import or export of asbestos fiber or products.

3.3.3.2 Demolitions and Renovations. For standards governing asbestos demolitions and renovations, 25 of the 51 regulations contained threshold levels lower than the current NESHAP. No regulations were identified that included different thresholds or work practices for nonfriable asbestos. Twenty-two (22) of the 51 regulations specifically required HEPA filters on negative pressure enclosures, and most States included special provisions for their operation and use. No regulations were identified that included provisions for viewing ports in the enclosure. Seven (7) of the 51 regulations included provisions for filtering shower water or otherwise managing excess water from wetting.

Thirteen (13) of the 51 regulations contained provisions addressing the use of wetting agents. Three of the 13 States require that the agent must consist of 50 percent polyoxethlylene ether or 50 percent polyoxyethlene polygyclol ester or equivalent and be mixed with water to provide a concentration of 30 mL (1 oz) surfactant to 19 L (5 gal) of water. Thirty-eight (38) of the regulations exceeded notification requirements in a variety of ways (e.g., apply to more projects, require more information, or additional notification forms, such as for waste disposal).

Nearly all the regulations (47 of 51) establish specific licensing, certification, and training requirements for contractors, supervisors, workers, inspectors, consultants, project designers, project monitors, and/or O & M personnel performing small abatement projects. Many of the States also have requirements for training course teachers and for the subjects to the covered in the courses.

Twenty-two (22) of the regulations have applied AHERA requirements for clearance air monitoring to all significant abatement jobs. Nineteen of these States require monitoring results to be less than 0.01 f/cm^3; three require a 0.005 f/cm^3. Most States allow analysis by phase contrast microscopy (PCM) or TEM; however, the number of samples required and the number that must meet the standard vary widely. For example, although some States require that the average of the samples meet the limit, others require each sample to meet the limit. Nearly all of these States have established premonitoring cleanup procedures requiring wet cleaning and HEPA vacuuming until no visible residue is present. Smaller jobs typically are exempt from monitoring, but not from cleanup requirements. Additionally, some States exempt demolition jobs from monitoring under certain conditions, but require compliance with the no visible residue standard.

Based on current information, two States have established requirements specifically for preventive maintenance, and at least eight more have onetime inspection and repair requirements for public building or for public and commercial buildings. Some of these regulations require inspection of the completed abatement every 6 months to ensure there are not any subsequent problems. Five States were identified that have developed supplemental protocols for bulk sampling for use in their inspection and repair programs.

3.3.3.3 Waste Disposal. Thirteen (13) of the 51 regulations include provisions governing inactive or abandoned waste disposal sites; three of the State regulations are asbestos-specific. In general, the 13 States require that a 60-cm (2-ft) final cover be applied or that the sites meet closure standards for active sites. Nearly all States have closure standards under their solid waste disposal regulations.

Thirty-five (35) of the 51 regulations include asbestos-specific provisions for waste handling prior to disposal. The major focus of the work practices is proper containerization. Twenty-one (21) of the 35 States specify the use of a single 6-mil polyethylene bag in a drum, double 6-mil bags, drums for waste with sharp edges likely to tear bags, and/or double 6-mil polyethylene sheets for large structural units removed intact. Two States allow double 4-mil bags, and 5 States allow single 6-mil bags.

Thirty-one (31) of the 51 States require specific work practices for disposal of asbestos waste at the landfill. Many different types of requirements have been established, such as inspection of the containers by the landfill operator, burial in a separate cell and/or trench, provisions for burial in the active face of the landfill, application of cover material immediately upon receipt, and differing requirements for the initial cover. Nine (9) of the 31 States exceed the NESHAP requirements for a 15.2-cm (6-in.) daily cover. For example, 30 cm (1 ft) of initial cover is required in Alabama; 23 cm (9 in.) in Connecticut; 60 cm (2 ft) of solid waste or soil or 120 cm (4 ft) if in a separate pit in Kentucky; 90 cm (3 ft) in New Jersey; 60 cm (2 ft) in Oregon; 60 cm (2 ft) of solid waste or 15.2 cm (6 in.) of earth in Rhode Island; 30 cm (1 ft) of earth or 90 cm (3 ft) of solid waste in Texas; and 30 cm (1 ft) of soil in Virginia and West Virginia. These States generally do not require an intermediate cover.

Eight State regulations were identified that include specific provisions regarding the compaction of cover material for asbestos waste. In one State, the initial cover is not compacted at all; the other States allow compaction only after the initial cover has been applied. Nearly all States have nonasbestos-specific provisions requiring solid waste to be compacted before burial.

Twenty-nine States have developed solid waste disposal regulations requiring an intermediate cover in addition to the 15.2 cm (6 in.) daily cover requirement. Five (5) of these States require 15.2 cm (6 in.) in addition to the initial cover within time periods ranging from 48 hr to 6 months. The remaining States require 30 cm (1 ft) of intermediate cover within time periods ranging from completion of the lift to 9 months after completion of the lift.

Forty-five of the 51 State regulations have general (i.e., nonasbestos-specific) regulations for final covers at solid waste disposal sites. A total of 30 States require a 60-cm (2-ft) compacted final cover or earthern material; 2 States offer an alternative of 60 cm (2 ft) of earth or a membrane cover or 46 cm (18 in.) of earth covered with 15.2 cm (6 in.) of topsoil. Four States specifically require 46 cm (18 in.) of earth covered by 15.2 cm (6 in.) of topsoil. One State allows 30 cm (1 ft) of final cover and two States allow 76 cm (30 in.). Six States require 90 cm (3 ft), although the cover may be 76 cm (30 in.) with 15.2 cm (6 in.) of topsoil. The final covers of earth typically are graded, vegetated, and maintained after closure.

Twenty (20) State regulations were identified that include asbestos-specific provisions for storage and transport. Although the requirements vary widely, nine States establish requirements such as for locked dumpsters or time/volume limits for temporary storage (e.g., store only to accumulate for disposal, limit of 500 209-L (55-gal) drums at the abatement site and 20 days at the disposal site, 5 days at the abatement site, storage of no more than 15.2 m^3 (20 yd^3) for 90 days or less, etc.). For transport, two States require the vehicle to be lined with polyethylene sheeting; two require the transporter to provide advance notification to the disposal site; two require a special waste manifest; and two require the transporter to be permitted. Two States require that the asbestos waste be segregated from other waste during transport, and one State requires a certified worker or supervisor to escort the transport vehicle to the disposal site.

Fourteen (14) of the 51 regulations have provisions requiring a cover for the transport vehicle or transport in an enclosed cargo area. Five State regulations were identified that require decontamination of the transport vehicle using wet cleaning methods or HEPA vacuuming. In one State, cleaning is not required if the cargo area has been lined with sheeting and no visible residue is present.

Although most States have solid waste disposal regulations for demolition landfills, no regulations were identified that were asbestos-specific. Typically, waste contaminated with asbestos (or other toxic material) is not allowed in demolition/renovation landfills, but must be placed in municipal or other asbestos landfills.

3.3.3.4 Spraying, Insulation, and Roadways. Four (4) State regulations were identified that prohibit the spraying of asbestos-containing materials. Five additional States do not prohibit spray applications, but apply more stringent control requirements (e.g., HEPA filters, respirators, containment barriers and vacuum cleanup, materials must contain less than 0.1 percent asbestos, materials contain less than 0.25 percent asbestos). Four states require nonasbestos substitutes to be used in patching or replacing thermal insulation and fireproofing; one of these States prohibits insulating material containing any amount of asbestos. Although no State regulations were identified that absolutely prohibited the use of asbestos tailings to surface roadways in the area of ore deposits, two State regulations specify that deposition of asbestos tailings on roadways covered with snow or ice is "surfacing" and prohibit it.

3.4 BASELINE EMISSIONS

Baseline emissions are the emissions that occur in the absence of additional EPA standards. Thus, baseline emission are those that result under the current NESHAP, as well as OSHA, Mine Safety and Health Administration (MSHA), and State regulations. Federal, including EPA, and State regulations for asbestos are discussed in Section 3.3.

Baseline emissions have been estimated for milling, manufacturing, and fabricating and for demolition and renovation. Emission estimates and the methodology used to estimate emissions are described in the following sections.

3.4.1 Mills and Manufacturing

Emission estimates for mills and manufacturing sources were derived from the following 1981 confidential business information (CBI) items submitted by 291 plants under authority of Section 8(a) of TSCA:

1. Asbestos consumed--tons/year
2. Control device waste collected--kilograms/year (pounds/year)
3. Asbestos content of control device waste--percent
4. Control device efficiency--percent
5. Control device gas volume--cubic meters per minute (cubic feet per minute.

Uncontrolled emissions were used as the basis for estimating controlled emissions and were computed for each control device using the following equation:

$$\text{Uncontrolled emissions (kg/yr)} = \frac{\text{Waste collected} \times \text{Asbestos content}}{\text{Control device efficiency}} .$$

For some sources, one or more of items 2, 3, or 4 from above were missing. For these cases, minimum, maximum, and average values were computed on a source category basis and were used to fill the data gaps (see Table 3-1). For control device waste and asbestos content, averages were weighted by asbestos consumption quantities. For efficiency, averages were weighted by gas volumes. Emission estimates were based on a best estimate and were adjusted to 1989 by using the ratio of 1981 to 1989 asbestos consumption in the United States.

Controlled emissions were computed using the following equation:

$$\text{Controlled emissions (ton/yr)} = \text{Uncontrolled emissions} \times \frac{(100 - \text{Time-weighted average efficiency})}{100} .$$

The method used to calculate controlled emissions is set forth in Appendix C. Nationwide emission estimates for 1989 are shown in Table 3-2.

3.4.2 Fabrication

Emission estimates for 62 fabrication sources were also derived from the confidential TSCA data and adjusted to 1989 consumption levels. Only sources currently covered by the NESHAP were evaluated. The emission estimates were based on the following data:

1. Control device waste collected--kilograms per year (pounds/year)
2. Gas volume--cubic meters per minute (cubic feet per minute)
3. Control device efficiency--percent
4. Asbestos content of control device waste--percent.

Uncontrolled and controlled emissions were computed based on the same equations used for mills and manufacturing.

For some sources, one or more of items 1, 3, or 4 were missing. For these sources, minimum, maximum, and average values were computed and were used to fill the data gaps. These values were all based on gas volume because it was not possible to compare production rates for various fabrication sources. Emission estimates for fabrication sources are presented in Table 3-2.

TABLE 3-1. FACTORS USED TO ESTIMATE UNCONTROLLED ASBESTOS EMISSIONS[a]

Product category	Uncontrolled emission factor (kg/ton)--total particulate			Asbestos content of baghouse waste (%)			Control equipment efficiency (%)		
	Min.	Max.	Avg.	Min.	Max.	Avg.	Min.	Max.	Avg.
Milling	806.4	2,098	1,281	5	5	5	99.7	99.99	98.833
Paper	0.0017	13.67	0.6563	6	6	6	95.0	99.95	99.044
V/A tile	2.440	1,706	81.28	5	8	6.641	99.9	99.99	99.926
A/C pipe	175.7	260.7	212.3	10	18	14.95	98.9	100.0	99.761
A/C sheet	248.7	1,388	639.6	20	20	20	90.0	100.0	99.714
Friction	14.88	4,835	1,014	14.7	66.7	43.61	99.0	99.9	99.352
Textiles	16.69	49.31	36.01	80	90	88.46	60.0	99.9	94.454
Packings/gaskets	0.103	9.03	1.307	95	95	95	99.0	100.0	99.987
Coatings and sealants	0.000635	2,835	7.085	0.01	100	57.3	50.0	100.0	98.344
Plastics	16.1	4,273	956	3	100	47.2	90.0	99.99	99.388
Insulation	13.2	102.8	79.3	18	18	18	90.0	99.0	97.607
Other	0.077	6,827	73.2	17	50	17.2	80.0	100.0	97.024
Primary mixed	0.00191	999	33.8	5	100	35.3	65.0	100.0	98.327
Primary, secondary mixed	3.57	22.7	6.23	80	80	80	99.8	100.0	99.982

[a] Where individual plant data were insufficient for estimating emmissions, the appropriate factors were used.

TABLE 3-2. NATIONWIDE ASBESTOS EMISSIONS FROM MILLING, MANUFACTURING, AND FABRICATION, 1989 (kg/yr)

Source category	Current NESHAP	
	Uncontrolled	Controlled
Milling	2,352,000	329
Manufacturing		
Friction	2,635,000	494
A/C pipe	257,000	36
A/C sheet	217,000	26
Paper	26,000	8
Coatings, sealants,	31,000	17
Plastics	162,000	34
Textiles	19,000	3
Packings, gaskets	12,000	1
V/A tile[a]	25,000	8
Fabricating	304,000	63
Total	6,040,000	1,020

[a]This product is not to be manufactured after August 1990.

3.4.3 Demolition and Renovation

See Appendix C for estimates of emissions under current NESHAP.

3.4.4 Waste Disposal

Emissions from disposal of demolition and renovation wastes were estimated by using emission factors developed from AP-42 and applied to estimated quantities of waste. The procedures for developing the emission factors and an estimate of their quality are described in Appendix C. Quantities of waste were estimated from the average number of demolitions and renovations (above the current NESHAP threshold) expected to take place each year. For the approximate 2,300 demolitions per year, emissions under current compliance with the NESHAP are expected to be 470 kg/yr (1,040 lb/yr). If the NESHAP were fully complied with, this value would decrease to 0.7 kg/yr (1.5 lb/yr).

For the approximate 56,000 renovations per year, emissions under current compliance with the NESHAP are expected to be 3,084 kg/yr (6,850 lb/yr). At full compliance this value would decrease to 2.3 kg/yr (5 lb/yr).

3.4.5 Removal and Recycling of Asbestos Pavement

The extent of asbestos-containing pavement is small, amounting to an estimated 16,000 km (10,000 miles). Because most of the pavement was laid as a surface layer in the 1960s and 1970s, it is likely that a large portion of the material has already been removed and discarded. Based on 16,000 km (10,000 miles) of 19 mm (3/4 in.) paving, the total asbestos content would be about 198 Mg (220 tons). Emissions from removing the pavement would occur during operations that are performed to saw and break up the material into slabs for removal. However, the sawing operations are generally performed with wet saws, and debris from the removal process is recycled or disposed of in municipal landfills. It is unlikely that significant emissions exist from the removal process.

To extend the life of pavement, it may be milled to smooth its surface. This operation is also performed with water-cooled equipment, and the wet debris is swept, collected, and recycled or disposed of in a landfill. As with the removal process, it is unlikely that significant emissions exist from milling.

Where recycling of paving is practiced, controls at the asphalt plant are usually baghouses or scrubbers on the drum mixer. For portable plants the control is more likely to be a scrubber because baghouses are harder to transport. Federal particulate standards (NSPS) for the plants are 0.04 gr/dscf and 20 percent opacity. Particulate matter emission points are controlled either by dust suppression techniques or by hooding and ducting to the control device. Asphalt plants now tend to be very clean. There is no longer the layer of fine dust that formerly was found coating everything at the plant.

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4.0 EMISSION CONTROL TECHNIQUES

Methods potentially applicable for control of asbestos emissions are discussed in this chapter. Fabric filtration, scrubbing, electrostatic precipitation, and high-efficiency particulate air (HEPA) filtration as they apply to controlling particulates; emission control methods for the demolition, renovation, and construction industry; and control of emissions from waste disposal are reviewed. Controls for spraying and roadways and encapsulation as a control method are examined. For milling, manufacturing, and fabrication sources, asbestos emission control usually involves application of local exhaust ventilation (LEV) followed by removal of asbestos with a control device. Discussion in Chapter 4 is limited to the types of control systems employed for milling, manufacturing, and fabricating sources. Details of the various systems applied and their costs for specific milling, manufacturing, and fabricating sources are given in Chapters 5 and 7. Chapter 4 includes more information on specific applications for demolition and renovation and waste disposal sources than for milling, manufacturing, and fabricating sources. Chapter 7 includes additional information on control costs for the latter source categories.

4.1 CONTROL SYSTEMS

4.1.1 Fabric Filters

Housed in a structure known as a baghouse, fabric filters are one of the most effective methods for removing solid particles from gas streams. During filtration, a dust-laden gas stream is passed through a woven or felted material in the shape of a cylindrical or flat supported bag, depositing dust on the dirty side of the filter. Dust is deposited on the filter by direct interception, inertial impaction, diffusion, electrostatic attraction, gravitational settling, and sieving. A mat or cake of dust forms on the filter surface, improving its collection efficiency.

Eventually, the combined resistance to air flow of the filter and filter cake increases to the point that air velocity across the filter and in the entire exhaust system decreases. At some predetermined resistance level (determined by pressure drop across the filter), the filters are cleaned by one of a variety of cleaning mechanisms. These cleaning mechanisms are a distinguishing feature among baghouse designs.

Filters may be cleaned by fabric flexing or reverse air flow. Fabric flexing can be accomplished by manual, mechanical, or air shaking. Air shaking is further separated into air bubbling, jet pulsing, reverse-air flexing, and sonic vibration. Reverse air flow consists of three methods: repressuring cleaning, atmospheric cleaning, and reverse-jet cleaning. For each, advantages and disadvantages exist that must be considered in the overall design of a fabric filtration system for each industrial application.

A variety of filter material is available; actual selection is determined by factors such as gas stream temperature and moisture, available space, cleaning method, and costs. Fabric filter cloth is either woven or felted. Woven fabrics generally operate at lower air-to-cloth ratios than do felted fabrics, therefore requiring more cloth area for the same amount of exhaust gas. Felted bags are used in reverse-jet and pulse-jet baghouses.

A 1974 survey by EPA of plants that used asbestos revealed that 80 percent of the respondents used baghouses and 90.1 percent of all control devices used were baghouses.[1] In addition, another 4.4 percent of the plants used baghouses preceded by cyclones, a combination representing 3.2 percent of total control devices used. Data collected by EPA under the Toxic Substances Control Act (TSCA) show that in 1981 baghouses were still the predominant method for controlling asbestos emissions. Table 4-1 summarizes the information on control device use, including baghouse use.

The 1974 survey showed that cotton was the fabric used in the majority of baghouses (see Table 4-2) and that mechanical shaking was the cleaning method used most often (see Table 4-3). Air-to-cloth ratios ranged from 1 ft/min to over 10 ft/min (see Table 4-4). Ratios for mechanically shaken baghouses were generally less than 3 to 1, while reverse-jet baghouses had air-to-cloth ratios of 4 to 1 and greater. Pressure drops for a majority of the baghouses surveyed operated at under 3 inches of water (see Table 4-5).

TABLE 4-1. DUST CONTROL DEVICES[2]

Control device	Plants using device		Total devices used	
	No.	Percent	No.	Percent
Baghouse	72	80.0	335	90.1
Scrubber	6	6.8	8	2.1
Cyclone-baghouse combination	4	4.4	12	3.2
Cyclone	4	4.4	7	1.9
Filter systems	3	3.3	6	1.6
Scrubber-baghouse combination	1	1.1	4	1.1
Total	90	100.0	372	100.0

Source: Harwood, C. F., P. Siebert, and T. P. Blaszak, Assessment of Particle Control Technology for Enclosed Asbestos Sources. Office of Research and Development, U.S. Environmental Protection Agency. Research Triangle Park, NC. Publication No. EPA-650/2-74-088. October 1974. 126 p.

TABLE 4-2. BAG FABRIC[3]

Fabric	Plants using fabric		Baghouses using fabric		Bag-cleaning mechanism used no. (%)			
	No.	Percent	No.	Percent	Hand shaker	Automatic shaker	Reverse jet	Pulse jet
Cotton	36	62.3	164	72.2	27 (16.4)	125 (76.8)	10 (6.7)	2 (1.2)
Dacron	8	13.8	31	13.7		23 (74.2)	3 (9.7)	5 (16.1)
Polyester	5	8.6	15	6.6		--	5 (33.3)	10 (66.7)
Canvas	2	3.4	4	1.8		4 (100.0)	--	--
Wool	2	3.4	2	0.9		2 (100.0)	--	--
Nylon	1	1.7	4	1.8		4 (100.0)	--	--
Orlon	1	1.7	3	1.3		3 (100.0)	--	--
Polyprolene felt	1	1.7	3	1.3		--	--	3 (100.0)
Polyphrone felt	1	1.7	1	0.4		--	1 (100.0)	--
Burlap	1	1.7	--	--				
Total	58	100.0	227	100.0				

Source: Harwood, C. F., P. Siebert, and T. P. Blaszak, Assessment of Particle Control Technology for Enclosed Asbestos Sources. Office of Research and Development, U.S. Environmental Protection Agency. Research Triangle Park, NC. Publication No. EPA-650/2-74-088. October 1974. 126 p.

TABLE 4-3. BAG-CLEANING MECHANISM[4]

Cleaning mechanism	Plants using mechanism		Baghouses using mechanism	
	No.	Percent	No.	Percent
Automatic shaker	39	59.0	160	63.3
Pulse jet	10	15.2	28	11.0
Reverse jet	9	13.6	33	13.1
Hand shaker	8	12.2	32	12.6
Total	66	100.0	253	100.0

Source: Harwood, C. F., P. Siebert, and T. P. Blaszak, Assessment of Particle Control Technology for Enclosed Asbestos Sources. Office of Research and Development, U.S. Environmental Protection Agency. Research Triangle Park, NC. Publication No. EPA-650/2-74-088. October 1974. 126 p.

TABLE 4-4. AIR-TO-CLOTH RATIO[5]

Air-to-cloth ratio		Plants having ratio		Baghouses having ratio	
m/min	ft/min	No.	Percent	No.	Percent
≤ 0.62:1	≤ 2.0:1	3	14.3	22	20.0
0.63-0.75:1	2.1- 2.5:1	3	14.3	22	20.0
0.76-0.91:1	2.6- 3.0:1	6	28.6	23	20.9
0.92-1.24:1	3.1- 4.0:1	2	9.5	9	8.2
1.25-3.10:1	4.1-10.0:1	7	33.3	34	30.9
Total		21	100.0	110	100.0

Source: Harwood, C. F., P. Siebert, and T. P. Blaszak, Assessment of Particle Control Technology for Enclosed Asbestos Sources. Office of Research and Development, U.S. Environmental Protection Agency. Research Triangle Park, NC. Publication No. EPA-650/2-74-088. October 1974. 126 p.

TABLE 4-5. PRESSURE DROP ACROSS BAG[6]

Pressure drop (cm [in.] H_2O)	Plants with Δp[a]		Baghouses with Δp		Bag-cleaning mechanism used no. (%)			
	No.	Percent	No.	Percent	Hand shaker	Automatic shaker	Reverse jet	Pulse jet
$\Delta p \leq 2.54$ (1)	2	10.0	2	2.0	--	2 (100.0)	--	--
2.54 (1) $< \Delta p \leq 5.08$ (2)	3	15.0	40	39.2	7 (17.5)	16 (40.0)	10 (25.0)	7 (17.5)
5.08 (1) $< \Delta p \leq 7.62$ (3)	5	25.0	17	16.6	--	11 (64.7)	4 (23.5)	2 (11.8)
7.62 (3) $< \Delta p \leq 10.2$ (4)	10	50.0	43	42.2	7 (16.3)	26 (60.4)	4 (9.3)	6 (14.0)
Total	20	100.0	102	100.0				

[a]Δp = pressure drop.

Source: Harwood, C. F., P. Siebert, and T. P. Blaszak, Assessment of Particle Control Technology for Enclosed Asbestos Sources. Office of Research and Development, U.S. Environmental Protection Agency. Research Triangle Park, NC. Publication No. EPA-650/2-74-088. October 1974. 126 p.

During 1981, information on emission controls was collected during visits to 13 milling, manufacturing, and fabricating sites that used over 120 separate control devices (see Table 4-6). Detailed information was not available in all instances, but baghouses were used overwhelmingly to control asbestos emissions, as shown in Table 4-7. The cyclone used in conjunction with a baghouse acted to return scrap material to the process and to reduce the load on the baghouse. The wet scrubber, with a pressure drop of 10.35 kPa (1.5 psi), was used to control emissions from a high-moisture exhaust gas stream. Table 4-8 summarizes the information collected on baghouse-cleaning mechanisms. Reverse-jet cleaning was used in 68 percent and shake mechanisms were used in 24 percent of the baghouses.

Advances in fabric filtration technology during recent years have been limited to introduction of fabrics capable of withstanding high temperatures and use of pneumatic cleaning devices.[7] Attempts are being made to augment the already high collection efficiency of baghouses through application of electrostatics and optimization of baghouse operations.

High exhaust temperature is not a serious problem for the asbestos industry. High temperatures are associated with drying of asbestos ore during milling. Nomex fabric filters typically are used for cleaning dryer exhausts in the mills visited.

The only other major advance or change that has occurred is the apparent increase in the use of pulse-jet filters in the asbestos industry. Generally, lower overall costs have made pulse-jet fabric filters increasingly popular wherever dust is collected from industrial processes.[8] Pulse-jet cleaning requires use of felted fabrics and allows higher air-to-cloth ratios, thus necessitating fewer bags for the same air flow. Pulse-jet filters typically have longer bag lives than do mechanically shaken filters. In addition, extra bags are often installed in shaker-cleaned baghouses to permit the closing off of a part of the baghouse for cleaning without interrupting production.*

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* However, in some asbestos plants, fabric cleaning is scheduled during normal production interruptions, such as during meal breaks and shift changes, to preclude the need for extra bags in mechanically shaken baghouses.

TABLE 4-6. PROCESSES AND NUMBER OF SITES VISITED

Process	Number of sites visited
Milling	3
Asbestos/cement (A/C) products	2
Textile products	2
Plastic materials	1
Friction products	2
Paper and felt	2
Chlorine	1
Total	13

TABLE 4-7. CONTROL DEVICE USE[a]

Control device	Number of plants using device	Total devices used
Baghouse	11	120
Cyclone-baghouse combination	1	1
Scrubber	1	1
Other[b]	2	1

[a]Information was collected during 1981 plant visits.

[b]One plant using a small amount of asbestos uses HEPA filters. Because of the nature of its product and its manufacturing process, another plant virtually has eliminated emission sources from within the plant, thus eliminating the need for air pollution control equipment for asbestos emissions.

TABLE 4-8. BAG-CLEANING MECHANISM[a]

Cleaning mechanism	Baghouses	
	Number	Percent
Pulse jet	83	68
Reverse air	10	8
Shaker	29	24
Total	122	100

[a]Information was collected during 1981 plant visits.

Potentially available technology applicable to fabric filtration was explored, and use of electrostatic augmentation to improve filter performance currently is being investigated. An electrostatic charge applied to exhaust particles or to filters or the imposition of an electric field across the fabric reportedly increases collection efficiency and reduces pressure drop.[9,10,11] Reduced pressure drop is apparently due to deposition on the filter of a more porous filter cake.[12] Currently, an electrostatic augmentation device is being marketed under the trade name "Apitron." In the Apitron, incoming dust is charged as it passes through a corona in charging tubes just before entering the open end of the filter bags. The filters and charging tubes are cleaned by a pulse of compressed air.

In another study sponsored by the U.S. Environmental Protection Agency (EPA), a pilot-scale baghouse was used to investigate electrostatic augmentation of fabric filtration.[13] A reverse-jet baghouse, electrostatically augmented, is being operated in parallel with a conventional baghouse (control) to eliminate dust from an industrial boiler slipstream. The electric field is maintained parallel to the fabric surface; corona particle charging is not used. Performance of the electrostatically augmented baghouse has been superior to the conventional baghouse in several ways, including:

- Reduced rate of pressure drop increase during filtration cycle
- Lower residual pressure drop
- Stable operation at higher face velocities
- Improved particle removal efficiency.

Reported low power consumption and modest expenditures for electrical hardware combined with the ability to operate at increased face velocities offer a favorable economic projection.

For some asbestos manufacturing operations an intermediate product is produced, which will be processed further to create a finished product. This process is often referred to as fabricating or secondary processing. Fabrication of the intermediate products can liberate asbestos fibers as in the cutting, grinding, or drilling of millboard, A/C sheet, or brake products. These operations are similar to the finishing steps in manufacturing, and emissions are controlled in the same way, typically by fabric filtration. Other fabricating operations are not likely to emit asbestos; e.g., in the asphalt saturation of asbestos felt for builtup roofing or pipeline wrap or in the vinyl coating of asbestos felt for vinyl sheet flooring. Air-cleaning devices associated with these operations used for controlling emissions from asphalt impregnating materials are not intended for asbestos control.

Although baghouses in the asbestos industry have a high mass efficiency (99.99 percent or greater), they may still release large numbers of small fibers.[14] Thus, research has been performed to optimize baghouse efficiency by controlling various operating parameters, such as relative humidity, air flow, dust loading, bag type, shake cycle, and series operations.[15,16] In a pilot-scale study,[17] the following qualitative conclusions were drawn:

- Relative humidity may affect the longer fibers' filterability, and high relative humidity adversely affects many bag fabrics.
- Total dust loading is less significant than dust type.
- Cotton fabrics seem equal in control capability and superior in resistance to relative humidity.
- Increasing air-to-cloth ratios (ranges selected in study) promote fiber removal.
- Higher shake amplitudes produce lower outlet concentrations.
- Shorter shake durations produce lower outlet fiber concentrations.
- Longer time periods between shake cycles (low frequency) produce lower outlet fiber concentrations.
- Exhaust recycle during bag stabilization may dramatically reduce outlet fiber concentration during stabilization of new bags (approximately 24 hours of operation).
- Two baghouses in series are not significantly more efficient than a single, stabilized baghouse.

A typical baghouse was selected, automated, and modified for stack sampling in a subsequent field study to assess the impacts on baghouse efficiency of shake amplitude, shake duration, and interval between shaking.[18] The conclusion was that long intervals between shaking, small shake amplitude, and short shake duration are apparently related to lower emission concentrations. Low emissions were thus related to the least frequent bag disturbances.[19]

As noted previously, baghouses normally achieve 99.99-percent control of emissions from asbestos industry sources. Occasionally, however, baghouses fail, with a resultant drop in control efficiency. Depending on the frequency and deviation of failures, the long-term efficiency of a baghouse may be as low as 99.66 percent. Appendix B discusses bag failures and the resulting decline in efficiency.

Inspection of baghouses at regular intervals can prevent or reduce the duration of such failures. Inspections examine both the internal and external components of the baghouse. Internal inspections examine bags for wear, abrasion and damage, condensation, tension, and state of bag connection. Inlet and outlet ducts and dust hoppers are inspected for dust buildup, and all surfaces are examined for evidence of corrosion. The external inspection focuses on the cleaning system and considers the following: operation without binding; loose or worn bearings; drive components; solenoids, pulsing values for Pulse-Jet; and compressed air system for Pulse-Jet and damper values. Air leakage from expansion joints, door gaskets, cleaning system penetrations, and hoppers is of interest as are the operation and lubrication of interlocks and the cleanliness, loose connections, and air filter of the control cabinet.[20]

4.1.2 Wet Collectors

Wet collection techniques are employed when particulates are not amenable to removal by fabric filtration. Water and other liquids are employed in conventional, wet collectors to entrap and remove particulates from gas streams. This action is accomplished by bringing droplets of scrubbing liquid into contact with the undesired entrained particles, primarily through inertial impaction, diffusive deposition, and direct interception, to render particle sizes large enough to permit high-efficiency collection. The mixture of collected material and scrubbing liquor is removed from the cleaning device to minimize reentrainment of the original contaminating material. Spray chambers, centrifugal spray scrubbers, impingement plate scrubbers, venturi scrubbers, packed-bed scrubbers, and centrifugal-fan wet scrubbers are among the many types of wet collectors used commercially.[21,22]

Under normal operating conditions, all control variables including scrubber pressure drop, recycle pump rate, makeup water rate, slurry density, slurry purge rate, and recirculation sump level should be operated in the defined ranges.[23] During normal operations, several items should be inspected routinely. Lines, nozzles, and pumps should be checked for plugging; and erosion/corrosion prevention liners, instruments, and other equipment parts should be inspected for wear.[24] Any damaged components should be repaired.

A primary disadvantage of using wet collectors as final-stage gas-cleaning devices to control asbestos emissions is the apparent low collection efficiency for submicron particulates. Some wet collectors, e.g., the venturi type, can be designed for improved efficiency in collection of submicron particle sizes, but operating costs are high due to the resulting higher pressure drops across the scrubbers. Wet collectors also produce a wastewater discharge. By 1983, asbestos-processing plants were to have zero discharge of asbestos-contaminated wastewater.

Table 4-1 indicates the limited use of wet collectors (scrubbers) by the asbestos industry as of 1974. Table 4-7 shows the number of scrubbers in use at 13 sites visited during 1981.

Because of the high energy requirements of conventional scrubbers, especially in collecting submicron particles, alternate collection forces have been investigated and applied to augment conventional scrubbers. Currently, two alternatives are available: electrostatic augmentation and use of phoretic forces. Electrostatic augmentation includes charged particle, oppositely charged droplet, charged particle with image charge on droplet, and charged droplet with image charge on particle.[25] Phoretic forces are active in wet scrubbers when temperature or water vapor concentration gradients exist between the particle and droplet environments.[26]

4.1.3 Electrostatic Precipitators (ESPs)

In an ESP, a corona is established between an electrode maintained at high voltage and a grounded collecting surface. Particulate matter passing through the corona is subjected to intense bombardment of negative ions that flow from the high-voltage electode to the grounded collecting surface. The particles thereby become highly charged within a fraction of a second and migrate toward the grounded collecting surfaces.[27]

ESPs are not used by the asbestos industry to control emissions. High installation cost and lower collection efficiencies (relative to those of fabric filters) do not make ESPs attractive to control asbestos emissions.

4.1.4 HEPA Filters

Limited information indicates that HEPA filters could be used after baghouses to provide improved asbestos control.[28] A wide variety of off-the-shelf cartridge filters are available with efficiencies for capture of 0.3-μm-diameter particulate varying from substantially zero to 99.999 percent. For purposes of this document, cartridges with efficiencies rated at 99.97 percent efficient or better are designated HEPA filters. Each cartridge is tested separately by its manufacturer and labeled with a serial number and with the tested penetration. Efficiency tests involve generating a 0.3-μm dioctyl phthalate aerosol and evaluating the effectiveness through an optical instrument according to Military Standard Number 282 or American Society for Testing and Materials (ASTM) Specification D-2986-71.

HEPA cartridge filters are available in a variety of sizes. However, a common size has a 61-cm by 61-cm (24-in. by 24-in.) face area and is about 31 cm (12 in.) thick. The cartridge is constructed of pleated filter media similar in appearance to the pleated construction of an automobile air filter. The pleated construction allows the packing of a large filter area in a small space. Gas-handling capacity varies for this size filter and ranges up to 60 m^3/min (2,000 ft^3/min) for a new 61-cm by 61-cm (24-in. by 24-in.) filter operating at a pressure drop of 1 in. of water.

There must be no leakage around the HEPA filter if it is to achieve its high efficiency. Consequently, the cartridges are constructed with rigid metal frames. The filter system is composed of one or more cartridges fitted to a rigid frame with gaskets sealing the space between the cartridges and frame. Because the cartridges must be replaced from time to time, the filter systems are designed so cartridges can be removed and replaced without affecting the effectiveness of the system.

For almost every application, preconditioning systems such as prefilters are required either to permit effective filtration or to optimize filtration costs. For each individual application, filter vendor or other expert advice should be obtained before selection of the preconditioning and filter system.

One reason for preconditioning is to optimize costs, which involves installing higher capacity, less effective, and less costly filters such as baghouses ahead of the HEPA filter. This action extends the useful life of the expensive HEPA filter cartridges. Baghouses are already commonly employed in asbestos milling, manufacturing, and fabricating.

At times a preconditioning system needs to be installed to minimize destruction or almost immediate blinding of the filter. If the gas temperature is too high, it will damage the filter; HEPA filters are available for temperatures up to 316 °C (600 °F). Excessive water or organics can cause problems, and tacky particulates and organic liquids can blind the filter in a short time.

With cooling systems involving water sprays, the effect of moisture on the HEPA filter must be considered. With excessive water in the gas, gas reheating or cooling followed by reheating must be employed, depending upon the application. Where a scrubber or spray cooler precedes a HEPA filter, effective mist eliminators need to be installed. With reheating, water problems can arise even at temperatures exceeding the vaporization temperature because not enough detention time is allowed for vaporization. When the particulates are tacky and would tend to blind the HEPA filter, it is usually necessary to install a scrubber to minimize problems. Although not demonstrated, one U.S. vendor of HEPA filters feels that they could be used after scrubbers without difficulty. However, others have expressed some concern over their use after scrubbers and feel some intervening dehumidification step would be required.[29]

When new, most HEPA filters are designed to operate at 1 inch of water pressure drop. A cartridge is replaced whenever the pressure drop reaches 2 to 3 inches of water, depending upon optimum costs. Vendors normally specify maximum recommended pressure drop and temperature and provide advice on other conditions that might adversely affect filtration. An accurate, sensitive pressure gauge is needed to determine when the cartridges should be replaced. Gas flow meters or indicators with or without recording capabilities also can be installed. Particle-counting systems monitor the effectiveness of HEPA filters in the field.

Because HEPA filters are seldom installed except where there is a need for stringent control, it is important to minimize contamination from replacement of cartridges or system maintenance. When cartridges are replaced or maintenance is performed, potential contamination problems are:

- Contamination of workers
- Clean side contamination
- Contamination of the work area
- Water pollution
- Waste disposal.

Recommendations and regulations for worker protection should be obtained from the Occupational Safety and Health Administration (OSHA). Removal of spent cartridges will involve some spillage of collected material, which can be limited mostly to the inside of the filter system if the contaminated cartridges are sealed in plastic bags. The area where the filter system is located should be protected from wind erosion, and the floor should be amenable to damp cleaning or vacuuming with HEPA-filtered vacuum cleaners. After the cartridges are enclosed in plastic bags or other closed containers, all gaskets should be inspected and removed if necessary and the entire work area and clean side of the filter system decontaminated by damp wiping techniques or vacuuming. All materials including protective clothing, rags, etc., should be sealed in plastic bags or other suitable containers. Excess water, which would cause contamination or water pollution problems, should be avoided. In some cases, the plastic bags are put in closed-top fiber drums or other heavy-duty containers to minimize damage to the plastic bags prior to disposal. All contaminated materials should be disposed of according to applicable waste disposal regulations.

Cleaning HEPA filter cartridges destroys the integrity of the cartridge and may impair its effectiveness. Some HEPA filter systems are designed for cleaning the filter element to extend useful life. Whether or not these systems should be employed should be decided on a case-by-case basis.

Once the used cartridges have been removed and the entire facility decontaminated, replacement cartridges can be installed. These should be inspected to ensure that they are new and have been tested and that there are certification documents, if such documents have been specified. When gaskets have been removed, they should be replaced. The cartridges should then be inspected for any physical damage that might have been caused after testing, after which the new cartridges should be installed with all seals secure. Techniques are developed for generating a dioctyl phthalate aerosol at the site and evaluating the system's effectiveness through particle-counting instruments to ensure the integrity of the system after replacement of cartridges.

4.2 DEMOLITION, RENOVATION, AND CONSTRUCTION

4.2.1 Demolition and Renovation

Methods used to control asbestos emissions from asbestos abatement operations performed as part of demolition and renovation commonly take the form of work practices (including encapsulation). Controls discussed below include those currently required by the standard as well as methods that are more stringent than those in the current National Emission Standard for Hazardous Air Pollutants (NESHAP) and that are being considered as regulatory alternatives (see Chapter 5).

Demolition of a structure may be done by any of several methods, including ball and clam demolition, floor-by-floor demolition, or implosion, and involves tearing down and ripping out walls, ceilings, piping, and other structural elements. To control asbestos emissions from demolition, the NESHAP requires that asbestos-containing material first be removed. Asbestos-covered structures may be removed from the structure in sections or units, or, while still in place, the asbestos may be scraped or chipped off or otherwise stripped from the surface with which it is in contact. Stripping and removing asbestos and encapsulating materials that contain asbestos will release asbestos fibers to the air. Handling and collecting asbestos-containing debris or waste is another potential emission source associated with asbestos removal activities.

4.2.1.1 Wetting Agents. The most effective control technique for reducing emissions is to wet the asbestos sufficiently before disturbing it. The advantage of wet removal over dry removal is that water can alter the aerodynamic characteristics of the fibers, making fiber release more difficult during the removal. The use of amended water (water to which a surfactant or wetting agent is added), which is more efficient at wetting the fibers, reduces water runoff because less water is needed to achieve the same effect as unamended water; also, amended water reduces work time because less time is required for airborne asbestos levels to return to background levels.[30] A mixture of water, polyoxyethylene ester, and nonflammable polyoxyethylene ether has been recommended (28 g [1 oz] in 19 L [5 gal.] of water).[31]

Ideally, the material should be wet with a fine spray several hours (even as much as 24 hours) before removal begins, with rewetting just prior to and during removal. Wetting may be by a standard water hose with a nozzle that permits the use of a fine, low-pressure spray or with airless spray equipment. Care should be taken in wetting that the water pressure does not dislodge the asbestos and scatter it about, with the potential of it drying later and being reentrained to the air. Such care is especially important in renovation where the facility is to be occupied, as in schools and office buildings. Excessive use of water also may damage property. Where the asbestos-containing material cannot be wetted because it has an impermeable outer jacket or coating, the outer coating should be cut sufficiently to allow water to reach the insulation.

In pilot demonstrations, premolded pipe insulation on Navy ships was wetted by injection of ethylene glycol (antifreeze) into the insulation.[32] Injection into the insulation solved the problem of wetting the asbestos through the water-repellent outer covering of the insulation and provided for complete wetting of the insulation. At least one injection system is available commercially that uses a proprietary chemical penetrant. The penetrant is pumped to an injection gun consisting of from 1 to 10 needles for varying degrees of coverage.[33]

In a report on the use of surfactants for asbestos removal, a surfactant was defined as "any compound that reduces surface tension when dissolved in water or water solutions; or which reduces interfacial tensions between two liquids or between a liquid and a solid."[34] The authors classified surfactants into three categories:

- Detergents
- Emulsifiers
- Wetting agents.

According to the report, detergents and emulsifiers do not penetrate as well as wetting agents, although detergents are rapid wetters. However, wetting agents cause water to wet and penetrate the asbestos material that is to be removed. Wetting agents increase penetration "by lowering the tensions" or "loosening the skin" that forms around water molecules forming drops of water on asbestos.[35] Due to the penetrating action of wetting agents, more individual fibers are wet. When combining water and a surfactant to make a solution of amended water, the authors noted that mixing the water with a surfactant at the removal site does not always permit adequate quality control to ensure a solution of consistent strength. Some manufacturers have developed wetting agents that are less concentrated, but are more efficient in application and are able to maintain a consistent wetting ability.

When choosing wetting agents for the wet removal of asbestos, the amount of the active ingredient, type of ingredient, and the type of asbestos must be considered. For example, sprayed-on asbestos may contain one type or a mixture of chrysotile, amosite, crocidolite, anthophyllite, tremolite, or actinolite. A blend of non-ionic surfactants containing polyoxyethylene esters of mixed organic acids, polyoxyethylene ethers of mixed organic acids, and polyoxyethylene ethers of alkylated phenols has been shown to be particularly effective.[36] Table 4-9 lists some commercially available wetting agents and their manufacturers.

An EPA study compared the effectiveness of controlling airborne asbestos levels using dry removal, wetting asbestos materials with plain water, and wetting with amended water.[37] Table 4-10 presents asbestos fiber counts for wet and dry removal methods studied. Concentrations in the tables were obtained through the U.S. Public Health Service membrane

TABLE 4-9. COMMERCIALLY AVAILABLE WETTING AGENTS FOR WET REMOVAL OF ASBESTOS IN BUILDINGS[a]

Wetting agent	Manufacturer and address
Asbestos-Wet	Acti P.O. Box 183 Maple Shade, NJ 08052
Certane 20-75	Certified Technologies 7404 Washington Ave. S. Eden Prairie, MN 55344
44-13, MEI Wetting Agent	Mon-Eco Industries, Inc. 5 Joanna Crt. East Brunswick, NJ 08816
CP-225, Chil-Sorb Wetting Agent	Childers 35555 Curtis Blvd. Eastlake, OH 44095
Superwet Wetting Agent	Better Working Environments, Inc. Stocking Warehouse 1400 Woods Run Pittsburgh, PA 15212

[a]The mention of product names is not a product endorsement by the EPA.

TABLE 4-10. COMPARISON OF METHODS IN REMOVAL OF AN 8- X 12-FOOT CEILING SECTION[38]

	Number of samples	Asbestos fiber counts (f/cm^3) Mean	Standard deviation
Dry: no preparation	11	82.2[a]	24.7
Wet: untreated water	6	23.1	4.9
Wet: amended water	10	8.1	4.6

[a]Membrane filters contained numerous fiber clumps in addition to counted fibers.

Source: Sawyer, R.N. Asbestos Exposure in a Yale Building. Environmental Research. 13:146-169. 1977.

filter method and represent worker exposure levels. Fiber release is substantially reduced with use of amended water over fiber release encountered with either dry or wet (and untreated water) methods. Compared to dry removal, the use of amended water reduced airborne fiber concentrations by 90 percent. A wetting agent of 50-percent polyoxyethylene ester and 50-percent polyoxyethylene ether in a concentration of 30 mL (1 oz) in 19 L (5 gal.) of water was used to obtain the results shown in Table 4-10.

In another report,[39] air samples collected from 52 recent asbestos removal projects were described and are summarized in Table 4-11. Area samples were collected inside and surrounding the work area during removal activities with National Institute for Occupational Safety and Health (NIOSH) analytical method P&CAM239. A total of 941 area air samples were collected during 52 asbestos abatement projects. Of these, 479 were collected inside the work area, and 238 were collected outside the buildings while the work was in progress. The arithmetic mean for all work area air samples was 2.5 f/cm^3. The geometric mean (GM), which better describes the air sampling data, was 0.74 f/cm^3 for all work area air samples. If divided into wet and dry removal, the GM for wet removal was substantially lower than for dry removal, 0.48 f/cm^3 versus 11.9 f/cm^3. Air samples collected outside the work area at locations where contamination would be likely had a mean concentration ranging from undetectable to 0.8 f/cm^3. The mean fiber concentration for samples collected outside the building where contamination might occur was 0.1 f/cm^3 or less.[41]

In addition to agents that enhance wetting, certain encapsulants are used during removal operations. Removal encapsulants are penetrating-type encapsulants that wet, coat, and encapsulate asbestos fibers. One removal encapsulant in use remains wet during removal and later hardens to help prevent the release of fibers. Table 4-12 lists some commercially available removal encapsulants. In one report on encapsulants, removal encapsulants are considered effective in wetting asbestos and controlling fiber release during application of the agent and subsequent removal because the removal encapsulant produces a wet material and reduces fiber release as it coats the fibers.[42] Removal encapsulants should be applied under low pressure using airless spray equipment to keep fiber counts at

TABLE 4-11. COMPARISON OF WET AND DRY REMOVAL METHODS[40]

Method	Number of samples	Number of projects	Asbestos fiber counts (f/cm^3)[a] Geometric mean	Geometric standard deviation
Wet	NR	45	0.48	2.3
Dry	NR	7	11.9	2.0
Total	479	52	0.74	5.0

NR = not reported.

[a]Area fiber counts using phase contrast microscopy.

Source: Ewing, W. M. (Georgia Institute of Technology), and G. J. Simpson (Gemco Construction Company). Air Sampling at 52 Asbestos Abatement Projects. (Presented at the American Industrial Hygiene Conference. Philadelphia. May 24, 1982.) p. 22.

TABLE 4-12. COMMERCIALLY AVAILABLE REMOVAL ENCAPSULANTS[a]

Removal encapsulants	Manufacturers
BWE 5000	Better Working Environments Stocking Warehouse 1400 Woods Run Pittsburgh, PA 15212
CP-240, Chil-Lock	Childers 35555 Curtis Blvd. Eastlake, OH 44095
MEI 44-45 Asbestos Removal Sealant	Mon-Eco Industries, Inc. 5 Joanna Crt. East Brunswick, NJ 08816
EPA 55	American Coatings Corporation 1500 Northwest 62nd St. Suite 503 Ft. Lauderdale, FL 33309
Control, Penetrating Removal Agent	Grayling Industries, Inc. 1008 Branch Dr. Alpharetta, GA 30201
Foster 32-60	Foster Products Corp. 1200 Walters Blvd. Vadnais Heights, MN 55110

[a]The mention of product names is not an endorsement by the EPA.

low levels. Low-pressure application using an airless sprayer capable of 242 to 345 kPa (35 to 50 psi) will allow more effective wetting without blowing the fibers into the air; higher pressures of 1,035 to 2,070 kPa (150 to 300 psi) should be used for misting the air and cleaned surfaces. According to this study, the advantages of using removal encapsulants are: "lower average fiber counts because of the settling and encapsulation of fibers during the application process; significant penetrating and saturating ability of the removal encapsulant; and the ability to render the asbestos waste nonfriable due to encapsulation, which reduces transport and post-disposal hazards due to bag breakage and water leaks."[43]

A disadvantage from an enforcement point of view for at least one removal encapsulant is the lack of evidence of moisture on asbestos-containing waste material. Manufacturers of this removal encapsulant suggest removing and bagging the asbestos material while the material is still wet.[44,45] Eventually, however, the removal encapsulant dries and the resulting coating is hard, with no evidence (such as water or condensation in the bags) of having been wetted. The only appearance change in the asbestos material when sprayed with one removal encapsulant, BWE 5000, is a slight sheen to the asbestos--typically no moisture is present in the bags.[46] A problem arises when an inspector does not observe work practices during the spraying, stripping, and bagging of the asbestos, but arrives at the removal site after the material is stripped and bagged. Inspectors often look at the bagged asbestos material to see if it is wet. If moisture is not seen in the bags, a violation may be issued to the asbestos contractor for not adequately wetting the asbestos. To convince inspectors that the material was wet during stripping and bagging, removal encapsulant manufacturers suggest adding a coloring agent to the encapsulant before spraying, such as food coloring or cloth dye.[47]

Although appropriate in most demolition and renovation jobs, use of wetting involves some limitations. Some types of amosite-containing materials (typically used in thermal insulation) will not adsorb water or amended water.[48] Safety considerations may dictate that water not be used. For example, the potential for electrocution prohibits use of water around electrical equipment or wiring. Water should not be applied to operating steam lines in confined areas, such as utility tunnels, where the steam generated from contact between the water and the hot pipe can burn the worker or create too hot an environment. Also, for safety reasons, the current NESHAP specifically exempts operations from certain wetting requirements when the temperature is below freezing and when it can be shown that it will unavoidably damage equipment.

4.2.1.2 Local Exhaust Ventilation. When EPA determines that equipment damage from wetting is unavoidable, a LEV and collection system must be used. Such a system also may be used in lieu of wetting for stripping asbestos from structural and functional members removed as units or in sections. LEV, as opposed to general room dilution (or space exhaust ventilation), captures particulates at or near the point of generation and prevents release of particulates into the surrounding work area. Typically, air volumes exhausted are less and exhaust velocities higher than those of space exhaust ventilation.

Due to the temporary nature of demolition and renovation work sites, LEV and collection systems at these sites differ from LEV systems used in permanent work sites such as manufacturing plants. LEV and collection systems commonly employed with asbestos removal and stripping consist of a portable or mobile vacuum system, flexible hosing that extends from the vacuum to the point of fiber release (usually without capture hoods), and an air-cleaning device. Portable vacuum systems, long used in the asbestos industry as part of housekeeping, typically are equipped with HEPA, or absolute, filters. Portable units have capabilities ranging from 20 to 70 L (5 to 18 gal.),[49] although at least one model can be used with a 209-L (55-gal.) drum. The relatively small capacities of portable units limit their practical application to jobs involving small to moderate amounts of asbestos, or, in the case of large renovation jobs, to jobs where the asbestos is being minimally disturbed, such as making cuts in the asbestos to remove structural or functional members in units or sections. Such portable vacuum systems are used frequently during cleanup following renovation. It is important not to overload the collection bags on these units because they may rupture and emit asbestos from the exhausts. Care also is required in their servicing, during which asbestos may be released. A HEPA-filtered vacuum may fail if used on wet material,[50] preventing its use for removing wet debris.

Another type of LEV system is the mobile vacuum removal system. These are transportable pneumatic conveying systems designed to pick up and move materials in solid, liquid, or slurry form. Mobile vacuum systems can be truck- or trailer-mounted and consist of a large-capacity collection box, a vacuum pump, and an air filtration system. Some vacuum systems have been modified for use with asbestos materials. Conventional vacuum trucks, however, may not be suitable for asbestos use because they do not have the necessary HEPA filters, performance monitoring systems, provisions for automatic shutdown, and design characteristics to facilitate controlled disposal of asbestos waste and decontamination or to minimize fugitive emissions.[51]

Mobile vacuum units are not used extensively by contractors because of their high initial costs and questions regarding their cost effectiveness.[52] However, when operated and equipped properly, such units have the potential to:

- Make the collection of asbestos rapid and simple.
- Quickly remove the contamination source from the work area.
- Maintain a relatively negative pressure in the work area.
- Reduce the personnel required to collect and dispose of the asbestos.[53]

Units can be used in high-rise asbestos removal jobs because several hundred feet of piping can be used with the vacuum unit.

Potential problems with mobile vacuum systems that can result in release of asbestos fibers into the atmosphere include:

- Disconnection of vacuum hoses
- Rupture or improper installation of fabric filter bags
- Use of relatively low-efficiency air-cleaning devices
- Use of asbestos-contaminated vacuum systems for nonasbestos jobs
- Filter bag replacement
- Poorly sealed doors or tailgates, unwelded seams, loose fitting joints, and leaky receiving chamber, which allow fugitive emissions during use or transport to disposal site
- Dumping of inadequately wet asbestos at the disposal site.[54]

When LEV and collection systems are used in lieu of wetting as permitted by the NESHAP, visible emissions from such systems are not permitted or the NESHAP's design and operation requirements for air cleaning must be met. From a practical standpoint, that NESHAP's equipment specifications (i.e., air flow permeability, maximum pressure drop, and fabric weight) are not applicable to small portable vacuum systems because, typically, their filtering systems differ from baghouses found in asbestos milling, manfacturing, and fabricating plants, for which the specifications were intended. Mobile truck- and trailer-mounted vacuum systems, however, frequently use small baghouses and would likely be capable of meeting either the no visible emission limit or the specifications for air-cleaning equipment.

Instead of tubular fabric bags, small, portable vacuum cleaners typically use a series of paper, cloth, or fiberglass or nylon filter pads and bags, including HEPA filters. Consequently, these units are more effective than baghouses. Manufacturer specifications for portable vacuum systems include container capacity (gallons), motor size (horsepower), suction pressure (inches or mercury), air flow (cubic feet per minute), etc. Although one manufacturer offers an optional manometer for its vacuum cleaners, it does not give numerical pressure drop readings but indicates when the main filter needs to be cleaned. Portable vacuum cleaners can meet the no visible emission limit easily. During tests on such systems, emissions were not evident in the exhaust even when disposable bags ruptured during use. This absence of emissions was believed to be due to the extensive filtering system in the vacuum cleaners.[55]

4.2.1.3 Negative Pressure/HEPA Filter System. Small, portable exhaust ventilation systems (generally referred to as negative-pressure or negative-air systems) are commercially available and have been used by contractors in many renovations. These systems use HEPA filters preceded by one or more prefilters to filter exhaust air. Portable systems have nominal ratings for moving up to about 60 m^3/min (2,000 ft^3/min) of air under clean filter conditions. Actual volumes under average operating conditions are nearer 30 m^3/min (1,000 ft^3/min).[56] Portable negative-pressure systems were evaluated for EPA in 1981, and unless noted otherwise the following discussion of such systems is derived from the report of that work.[57]

To determine the number of exhaust units needed for a project, the volume of the work area (cubic feet) is divided by the recommended frequency of air change (time for one air change in minutes) times the capacity of the unit (cubic feet per minute). The EPA recommends, as a minimum, four air changes per hour or one air change every 15 minutes.[58] The equipment generally is located at floor level and vented to the outside through windows or doors. The static pressure differential maintained across the barrier is usually low and variable (about 0.02 to 0.04 in. wg),[59] but can be easily measured with the use of a Magnehelic gauge. Smoke is used to visualize air flow patterns, to check barrier integrity, and to verify that the work area is negatively pressurized. This smoke testing, as well as static pressure measurement, is a recommended and reliable method for testing negative-pressure systems.

Exhaust air on these negative-pressure systems typically is cleaned by one or more prefilters followed by HEPA filters. Whenever possible, the cleaned exhaust should be vented to the outside and away from any occupied areas rather than back into the building.[60] The practice of venting exhaust units to adjacent areas generally is not recommended because the possibility of a filter failure cannot be eliminated. Alternatively, long, flexible ducts can be used to vent the air discharge through the enclosure opening to the outside of the building. Exhaust units can be located inside the enclosed work area with only the exhaust duct vented through the barrier, or they can be located outside the work area with only the grill face in the work area. The duct or unit is sealed to the barrier with duct tape. Either configuration is acceptable, assuming all filters are accessible through the grill, thereby containing any contamination generated during filter changes or maintenance in the enclosed work area.

Negative-pressure systems have been used during dry, manual removal operations to maximize fiber containment and reduce fiber levels in the work area. However, wet methods are recommended for all cases unless there are problems with freezing or equipment damage. Monitoring data demonstrating the effectiveness of dry systems show the system efficiency to be 99.207 percent.[61] Frequent changes of prefilters are necessary to maintain the air-handling capacity of the exhaust units and to keep the work area negatively pressurized.

Powered exhaust units vary in design and safety features. One system features automatic shutdown in the event of an abnormal pressure drop across the filters, a yellow warning light to indicate dirty filters, and a green light to indicate normal operation. Some systems rely solely on operator observation to determine if they are functioning adequately. Some units have elapsed-time indicators to record the hours of operation and timers that allow the units to run for a preset period and turn off automatically.

For large-scale abatement projects, where the use of a larger capacity, specially designed exhaust system may be more practical than several smaller units, the fan should be appropriately sized according to the proper load capacity established for the application; i.e.:

$$\text{Total ft}^3\text{/min (load)} = \frac{\text{Volume of air in ft}^3 \times \text{air changes/hr}}{60 \text{ min/hr}} .$$

In some instances, mobile vacuum systems can be used in conjunction with an enclosure system to maintain negative air pressure in the work area. This procedure could be used where space in the work area is insufficient for the negative-pressure equipment. A vacuum line could be run several hundred feet from the work area to the mobile vacuum unit.

Enclosures (containment barriers) may be required to provide a work space that can be kept under negative pressure when space exhaust ventilation is used. Containment barriers also can physically reduce migration of asbestos fibers beyond the work area as indicated by the fiber counts presented in Table 4-13. Plastic (polyethylene) sheets commonly are used to construct an enclosure or containment system. The work area should be isolated by sealing off all of its openings and fixtures including heating and ventilation ducts, doorways, corridors, windows, skylights, and lighting with plastic sheeting taped securely in place. Double barriers of plastic sheeting should be built at all entrances and exits to the work area so it is always closed off by one barrier when workers enter or exit. All floor and wall surfaces in the work area should be covered with plastic sheeting taped securely in place. Where wall surfaces are smooth and nonporous, the wall covering may not be necessary for protection. Asbestos fiber accumulation can be removed by HEPA vacuum equipment or wet cleaning

TABLE 4-13. INHIBITION OF ASBESTOS MOVEMENT BY POLYETHYLENE BARRIERS[62]

Removal method	Mean fiber counts (f/cm^3) Inner room (demolition)	Middle room (entry)	Outer room (staging)
Dry	74.4	6.4	2.0
Amended water	8.2	2.0	0.0

Source: Sawyer, R. N. Asbestos Exposure in a Yale Building. Environmental Research. 13:146-169. 1977.

during cleanup, as appropriate. Where surfaces are porous and irregular and are not going to be altered, plastic sheeting should be used to protect them. A tape should be used that can seal joints of adjacent sheets of plastic and can attach the plastic sheets to finished or unfinished surfaces of dissimilar material and capable of adhering under dry and wet conditions. It may be advisable to cover the floor with two layers of 6-mil plastic that extends up the walls to overlap the sheeting there.

For jobs involving small amounts of asbestos, or where the asbestos is not in a room that can be enclosed easily, an enclosure may have to be constructed around the work area. Enclosing a small area within a larger structure and using wood studs for the frame and plastic or plywood for the walls can prevent the need to prepare and restrict large areas. For tall, unsupported outdoor structures, it may be necessary to use scaffolding as the frame to which plastic sheeting can then be attached.

4.2.1.4 Glove Bags. Another control method that involves enclosures is the glove box or glove bag technique. Asbestos insulation may be stripped from small sections of pipe or other small areas through glove box or bag techniques. Glove boxes and bags have the advantage of isolating the worker from exposure to asbestos fibers and are an alternative to full room containment when only small areas are affected. Glove boxes are clear-sided containers with glove attachments constructed around surfaces from which asbestos materials will be removed. Construction of glove boxes is performed during site preparation. Glove bags are clear bags with glove attachments and openings for inlet air, air filters, tools, and wetting applicators that can be sealed around surfaces from which asbestos materials will be removed. Glove bags are commercially available and others can be manufactured at the job site.

General guidelines for the use of glove box and bag methods include maintenance of the containment before and during removal, inspection of the seals during removal, and recognition that staging or other support may be required. Removal methods in which glove boxes or bags are containment options require specification on fabrication, installation, use, removal, and repair.

Fabrication of glove bags (boxes) requires consideration of the job, spatial constraints, type of materials, and how the materials can be put together. Material required for fabrication includes the following:

- Plastic regulite--sheeting used as the basic material in bag fabrication, 6-mil thick, clear, and fire retardant
- Tape, double backed--1-inch width, used to seal seams on bag
- Contact cement--used to apply trash bag to glove bag (Armstrong 520)
- Duct tape--standard 2-inch-width tape
- Rubber gloves--unlined rubber industrial gloves
- Appropriately labelled trash bags
- Scissors--for cutting sheeting
- Brush--to apply contact cement.

The materials that function as containment barriers should be transparent so removal can be observed and inspected. Some materials that have been used are polyvinyl chloride (PVC), herculite, regulite, vinyl, or polyethylene. Lining barrier materials with heat-resistant materials at points and edges that touch hot surfaces may be required. Limiting the areas of contact is recommended. All seams should be sealed to contain asbestos fibers adequately. Glue, heat, velcro, zippers, and thread may be applicable. Sleeves for gloves and waste disposal are necessary, but sleeves for air inlets, filters for exhaust, wetting agent applicators, etc., may be desired.

Installation requires supporting and securing the bag (box) in the position that provides optimal use. Gloves and filters are attached to sleeves during installation. A plastic ring can be slipped over the sleeve and a portion of the sleeve is folded over the ring to attach the glove. The upper portion of the glove is folded over the sleeve fold and a rubber ring placed over the glove, sleeve, and plastic ring to secure the glove opening.

Hot surfaces that will come in contact with the bag (box) should be covered with heat-resistant material, and all unused sleeves should be sealed. Tight seals should be made around all bag openings with tape. For example, openings around piping may be sealed by wrapping the sleeve around the pipe with 1/8-inch soft rubber, tape, and a hose clamp. Hoses or applicators such as for a wetting agent should be installed as needed.

It is best to put on cotton or cloth gloves before the bag gloves so the bag gloves (rubber) slide off easily. If the bag must be opened, it should be kept under negative air pressure by use of a vacuum. The sides or walls of the bag (box) should be kept clean; water may be used to wipe them down. Waste should be passed through the waste sleeve as work proceeds.

For glove bag (or box) removal, all waste and loose dust should be removed from inside the bag (box) through the waste sleeve. The vacuum should be operating while the bag or box is removed. With the vacuum running, hoses, applicators, lights, or tools that may be attached to the bag should be removed. The glove bag should be placed in a clean plastic bag until thoroughly cleaned in a properly ventilated, exhaust-filtered area. If not reusable, the bag should be disposed of with other asbestos waste.

Holes and tears in the asbestos bag may be repaired with cloth-backed tape or with a strip of barrier material prepared with a silicone adhesive transfer tape. Drying time is necessary before work is resumed.

Surfaces sizes and shapes limit the feasibility of using glove bags (boxes). Asbestos removal from steam pipes may also require special methods other than bag (box) containments.

4.2.1.5 Controls for Nonfriable Materials.

4.2.1.5.1 Controls. The current NESHAP rule does not require removal of nonfriable asbestos-containing packings, gaskets, resilient floor covering, or asphalt roofing products prior to demolitions, but does regulate work practices that could result in emissions. For example, sanding, cutting, grinding, or abrading of these materials must be done wet and the waste produced must be treated as asbestos waste. Dry sanding, buffing, or other activities that would result in significant fiber would be prohibited. Nonfriable materials, such as asbestos-cement sheet, that would be crumbled, pulverized, or reduced to powder as a result of demolition or renovation forces must be removed according to the NESHAP work practices, which include wetting of the nonfriable material, placement in leak-tight containers with proper labels, and transport of the asbestos-containing waste to a NESHAP landfill. In addition to the NESHAP, OSHA and the Asbestos Hazard Emergency Response Act of 1986 (AHERA) both regulate the removal of nonfriable materials. OSHA regulations require negative pressure enclosures be installed whenever feasible.

Currently available techniques for tile removal include manual chipping with chisels and paint scrapers, although this method is being replaced by mechanical scrapers, steel shot blasting machines, infrared radiation equipment, and high-pressure water blasting.[63] Manual chipping commonly involves the use of long-handled paint scrapers. To make removal by chipping easier, contractors soak the tiles in water or amended water to loosen them from the floor. Water is not recommended when the tiles are on wooden floors. The application of dry ice can provide a quick and simple means of "popping" floor tiles so that they can be removed easily. A disadvantage with the dry ice method is that it can result in an oxygen deficiency in the area where it is used. Another method involves heating the tile with a heat gun. This loosens the tile adhesive (mastic) and makes removal easier. A disadvantage of the heat gun method is that the heat can result in vapors being generated from the tile or mastic that are potentially harmful.[64]

A mechanical steel shot-blaster that was developed for use by the U.S. Navy to remove the coating on flight decks of aircraft carriers has proven to be effective for removing asbestos floor tile and mastic. The shot-blaster consists of a wheel spinning at a high rate of speed. Steel shot is fed into the center of the wheel and is pushed outward at high speeds by centrifugal forces. The shot impacts the floor surface and "blasts" the tile and mastic away.[65] Portable shot blasters are used to "pulverize" the mastic using steel shot. These devices can reduce the labor and time requirements over manual methods. However, these units are expensive and must be used and maintained by trained operators to remove the mastic properly and safely without damaging floor surfaces. This method cannot be used on wood floors or other soft surfaces that might be easily damaged. Some asbestos consultants have been reluctant to use this "dry" method of removal or have been concerned about equipment contamination.[66]

Another removal technique for floor tile removal uses infrared radiation to loosen floor tiles. The infrared radiation breaks down the chemical bond formed by the adhesive with the surface by causing the adhesive and tile to heat up. The infrared removal equipment uses a highintensity infrared source that is contained in a protective covering. The machine is rolled over the floor tile surface, leaving the tile loose to be easily removed. The mastic is still in place and must be removed.[67]

A mechanized approach to the manual scraping/chipping method involves the use of a machine with rotating or reciprocating blades to remove the tile. Steel blades are rotated at high speed or moved back and forth to knock the tile away from the surface. An integral vacuum system sucks the dust and loose tile pieces into the collector.[68] Depending on the condition of the tile and mastic and the depth of the chipping action, it may be necessary to remove the remaining mastic material.

High-pressure water technology, used in the asbestos abatement business for quite some time, also can be applied to floor tile removal. Newly developed high-pressure water systems have overcome one of the major drawbacks to their use by reducing the quantity of water that is needed. However, the potential for property damage from the water exists and the mastic may not be removed by the high-pressure water method.[69]

Most tile removal methods leave the floor tile mastic attached to the subfloor. Frequently, the mastic also contains asbestos. Early removal methods included the use of industrial sanders or grinders to physically separate the mastic from the floor. Other available removal methods include the use of burning torches or infrared heaters to heat the mastic to soften it for easier removal with hand scrapers. These methods are often time-consuming and labor-intensive and may pose health, safety or fire risks.[70]

The most prevalent and popular method of mastic removal today uses chemical mastic removal solvents. These materials dissolve the mastic although some physical agitation may be required. Productivity is typically increased and the time necessary to complete the job is reduced. Chemical removers can also, if properly selected and applied, produce more thorough and complete results than manual methods without chemicals.[71] These materials can typically be applied with hand sprayers, mops, or squeegees directly from 5-gallon pails or 55-gallon drums.

Commercially available mastic removers fit into one of three general product categories: (1) petroleum distillates, (2) nonpetroleum products, and (3) blended products.[72] Petroleum distillates are relatively inexpensive, but effective, solvents. Aromatic hydrocarbons are listed by OSHA as hazardous substances, primarily because of their effects through inhalation. Examples of aromatic hydrocarbons found in commercially available mastic removers include naphthalene (threshold limit value [TLV] of 10 ppm) and 1,2,4-trimethylbenzene (TLV of 100 ppm). Use of chlorinated petroleum distillates, which may pose more serious health hazards--including skin, blood or central nervous system disorders--should be avoided wherever possible. Examples of such chemicals would be methylene chloride (also a suspected carcinogen) and trichloroethylene.

Nonpetroleum products are usually the citrus-based removers formulated from the crushed peels of oranges and other citrus fruits. These products, which are typically more expensive to produce than petroleum derivatives, are effective mastic removers. The natural, biodegradable solvents produced, particularly those made from concentrated "first run" citrus materials, react strongly with many petroleum-based mastics. These removers typically have a strong orange or citrus fragrance. However, for some mastics, the citrus solvents do not work or require additional time and/or agitation to release the mastic.

Some mastic removers use a "blend" of petroleum and nonpetroleum (usually citrus) solvents. The resulting products are typically less potent and slower acting than pure citrus solvents but are also generally less expensive. These blends usually "mask" the petroleum solvent odor with a citrus fragrance. Citrus solvents are also blended by a few manufacturers to produce a product with a higher flash point. Pure citrus extract has a flash point in the vicinity of 49 °C (120 °F).[73]

When removing sheet vinyl flooring, the Resilient Floor Covering Institute recommends that the flooring be cut into strips and rolled into a tight roll with the face out. The roll should be tied or taped so it will not unroll and then placed into a bag.[74] They also recommend vacuuming the exposed floor with a HEPA-filtered vacuum. The felt backing should be wetted with amended water prior to rolling up the strip. This procedure can be done for the entire floor area. Where any of the felt backing has adhered to the floor, it should be wetted with amended water and scraped up and put into a bag.[75] The floor should be cleaned with a HEPA vacuum cleaner.

Asphalt roofing materials include a variety of products, such as roofing felts, mastics, and base flashings. The potential for fiber release occurs when roofing workers cut, saw, or tear roofing materials. Methods employed during roof removals include the use of a shrouded roof cutter with controlled wetting or misting at the point of the cut. Attempts to use roof cutters in conjunction with local exhaust ventilation have been unsuccessful because the HEPA filters clog easily and require frequent filter changes.[76] Roof cuttings should be collected and bagged for disposal. Airtight chutes should be used for transporting larger sections of roofing to a truck or dumpsters.

Nonfriable packings and gaskets are found in conjunction with valves, piping, or equipment. Removal of gaskets and packings are usually associated with small-scale operations. Such operations can often be performed using glove bag techniques. The methods are described in Section 4.2.1.4 of this chapter.

The degree of control necessary for these and other nonfriable materials, such as asbestos-cement products, depends in part on the condition of the material and the removal methods. Nonfriable materials that are in good condition and can be removed essentially intact require minimal dust suppression efforts such as wetting. However, if the nonfriable materials are in a deteriorated state or the forces that will be exerted upon them are likely to crumble, pulverize, or reduce them to powder, dust suppression efforts would be needed, or steps would need to be taken to avoid having the material crumbled, pulverized, etc. This is often necessary for nonfriable asbestos-cement products in structures that will be demolished where the asbestos-cement is usually removed prior to demolition.

4.2.1.5.2 Fiber release data. In a study performed by GCA Corporation for the Office of Pesticides and Toxic Substances,[77] the fiber release potential of certain asbestos products during secondary processing (fabricating) and end use, including removal, were investigated. In some instances, airborne asbestos fiber concentrations associated with such activities were reported. The information presented in the report was compiled from an extensive survey of publicly available data and telephone interviews with manufacturers, secondary processors, distributors, and end users of asbestos-containing products.[78] Analytical methods included phase contrast microscopy (PCM) and scanning electron microscopy (SEM) used in conjunction with an energy dispersive x-ray (EDXR) spectrometer. Table 4-14 summarizes the fiber concentration data for removal operations associated with the various product categories with the exception of the A/C sheet category. Fiber release data were not found for A/C sheet removal activities. The fiber concentration data shown for A/C sheet are for secondary processing and end use activities.

Fiber concentrations associated with removal of vinyl-asbestos floor tile, sheet vinyl flooring backed with asbestos flooring felt, built-up roofing, packings and gaskets, and roofing felt were all below 2 f/cm^3 with one exception in the sheet vinyl flooring category (2.17 f/cm^3). Most concentrations were below 1 f/cm^3. The highest concentration, 2.17 f/cm^3, was recorded during the dry scraping of an asbestos felt layer of 6-yr-old sheet vinyl flooring covering. The authors of the GCA study noted that dry scraping is not the recommended work practice of the Resilient Floor Covering Institute. The only other fiber concentration greater than 1 f/cm^3 (1.2-1.3 f/cm^3) occurred during the removal of vinyl-asbestos floor tile. Removal of the floor tile was done by the belt sanding of old floor tile and was performed under laboratory conditions in a 10 x 12 x 7-foot walk-in chamber.

The higher fiber concentration for removal of the floor felt is expected because the felt contains a higher percentage of asbestos (85 percent) than the tile (8 to 30 percent) and is not as structurally cohesive as the tile.[80] The low fiber counts for floor tile in the GCA study are consistent with the results of other tests performed on vinyl floor tile, which showed that even when broken into small fragments, analysis by PCM failed to detect any airborne fibers.[81]

In another test, Arthur D. Little, Inc., was asked to measure airborne asbestos levels during the removal of Tremply 120, a roofing material consisting of sheets of encapsulated asbestos bonded to a heavier synthetic overlay.[82] The removal site was the roof of a manufacturing facility. All of the monitored exposures were below OSHA's action level of 0.1 f/cm^3 and the mean 8-hour time-weighted average (TWA) exposure was 0.017 $\pm$ 0.010 f/cm^3. The data are reported in Table 4-15. The investigator reported

TABLE 4-14. SUMMARY OF MEASURED AIRBORNE FIBER CONCENTRATIONS RESULTING FROM REMOVAL OF CERTAIN ASBESTOS PRODUCTS[79]

Asbestos product	Activity performed	Measured fiber concentration (f/cm^3)	Date of tests	Duration of activity/sampling time (min)	Analytical method	Comments
Vinyl-asbestos floor tile	Flooring removal, ripping up tiles	0.02-0.1	1980	165	SEM/EDXR	Monitoring performed during actual flooring removal. Results are more indicative of levels nearby the workplace than those actually experienced by the worker.
	Flooring removal by sanding rough surfaces remaining	1.2-1.3	1970-1971	20	Phase contrast	Simulated testing in laboratory chamber 3x3.7x2.1 meters with four air changes/hr. Belt sander with coarse paper used.
	Complete removal by recommended procedures[a]	0.062 to 0.147	1979	123 to 134	Phase contrast	Testing was performed in laundry room, powder room, closet, and hallway of a private home.
	Complete removal by a method that deviates from recommended procedures	0.153 to 0.583	1979	80	Phase contrast	Dry scraping and sweeping occurred during removal.
Sheet vinyl flooring backed with asbestos flooring felt	Partial removal by recommended procedures[b]	0.190 to 0.408	1979	44 to 62	Phase contrast	Material removed had been adhered to subflooring.
	Complete removal by recommended procedures	0.368 to 0.402	1979	121 to 123	Phase contrast	Material removed had been adhered to subflooring.
	Complete removal by recommended procedures	0.069 to 0.100	1979	74 to 76	Phase contrast	Material removed had not been adhered to subflooring.

(continued)

TABLE 4-14 (CONTINUED)

Asbestos product	Activity performed	Measured fiber concentration (f/cm^3)	Date of tests	Duration of activity/sampling time (min)	Analytical method	Comments
	Complete removal Wear layer removal	0.084 to 0.218	1979	70 to 75	Phase contrast	Material removed had been adhered to subflooring.
	Dry scraping of flooring felt	1.00 to 2.17	1979	40 to 63	Phase contrast	Material removed had been adhered to subflooring.
	Wet scraping of flooring felt	0.484	1979	55	Phase contrast	Material removed had been adhered to subflooring.
Built-up roofing	Tear-off	0.1 to 0.4	1974	NR	Phase contrast (assumed)	Monitoring performed in Indiana.
	Tear-off and replace (spray)	0.0 to 0.3	1974,1976	NR	Phase contrast (assumed)	Monitoring performed in Pennsylvania and Indiana.
Compressed asbestos sheet gaskets	Removal and concurrent installation (boiler header gaskets)	0.2 to 0.3	1978	21 to 95	Phase contrast	Housekeeping. Monitoring conducted under actual work conditions.
	Cleanup following removal by hand scraping	<0.05	1978	33 to 37	Phase contrast	No control. Monitoring conducted under actual work conditions.
	Removal and hand scraping	<0.06 to 0.39	1978	15 to 28	Phase contrast	No control. Monitoring conducted under actual work conditions.
	Removal and wire brushing	<0.03 to 0.18	1978	25 to 33	Phase contrast	Housekeeping. Monitoring conducted under actual work conditions.

(continued)

TABLE 4-14 (CONTINUED)

Asbestos product	Activity performed	Measured fiber concentration (f/cm^3)	Date of tests	Duration of activity/sampling time (min)	Analytical method	Comments
Packing - mechanical packings for pumps	Simulated removal of packing from pump	<0.1 to 0.1	1979	NR	Phase contrast (assumed)	Simulated removal occurred in open building, details of removal not reported.
Roofing felt	Sawing, scraping, sweeping old roof material. Cutting and laying new felts	0.00 to 0.05	1979	135	SEM/EDXR	Fiber concentration range includes area and personal samples taken during roof removal and felt installation.
	Cutting, scraping, sweeping old roof material. Cutting and laying new felts	0.0	1976	ND	Phase contrast	Fiber concentration of 0.0 f/cm^3 reported for 6 area and 4 personal samples taken during roof removal and felt installation.
	Sawing, scraping, sweeping old roof material. Cutting and laying new felts	0.1 to 0.3	1974	75-120	Phase contrast	Fiber concentration range includes area and personal samples taken during roof removal and felt installation.
	Sawing, scraping, sweeping old roof material. Cutting and laying new felts	0.0 to 0.2	1974	ND	Phase contrast	Fiber concentration range includes area and personal samples taken during roof removal and felt installation.
	Axe chopping, prying and scraping, sweeping old roof	0.1 to 0.4	1974	60-82	Phase contrast	Fiber concentration range includes area and personal samples taken during roof removal.
Asbestos-cement sheet	Drilling flat sheet	2.3 (2.3)	1981	5	NIOSH Method (SEM/EDXR)	Testing performed in glove box. Only fibers ≥5 μm in length counted, even when analyzed using SEM.
	Scoring flat sheets	3.2 (1.1)	1981	4	NIOSH Method (SEM/EDXR)	Testing performed in glove box. Only fibers ≥5 μm in length counted, even when analyzed using SEM.
	Hammering flat sheet	6.4-12.7 (10.2-16.5)	1981	4, 1	NIOSH Method (SEM/EDXR)	Based on two repetitions in glove box. Only fibers ≥5μm length counted, even when analyzed using SEM.

TABLE 4-14 (CONTINUED)

Asbestos product	Activity performed	Measured fiber concentration (f/cm^3)	Date of tests	Duration of activity/sampling time (min)	Analytical method	Comments
	Sawing flat sheet	195.8 (258.8)	1981	1	NIOSH Method (SEM/EDXR)	Testing performed in glove box. Only fibers ≥5 µm in length counted, even when analyzed using SEM.
	Drilling holes (163) in 0.64-cm (0.25-in.) thick flat sheet	0.1	1979-1980	40	Phase contrast (assumed)	Drill was equipped with dust pickup shroud that totally enclosed masonry blade.
	Sawing (18.3 meters) 0.64-cm (0.25-in.) thick flat sheet	0.0	1979-1980	40	Phase contrast (assumed)	Saw was equipped with dust pickup shroud.
	Sawing A/C board with a circular saw (carbide blade)	0.04	1979	12	Phase contrast	Saw was equipped with dust pickup shroud that vented to a Nilfisk HEPA-filtered vacuum cleaner.
	Sawing, drilling, and scrolling (sabre saw) A/C board	0.15	1979	17	Phase	Power tools were equipped with dust pickup shrouds that vented to a Nilfisk HEPA-filtered vacuum cleaner.
	Grinding corrugated sheet to cut stack of sheeting in open air; grinding to cut sheeting while on roof	0.6 to 41	1980	ND	Phase contrast	Testing performed outdoors on job site. Assumed no dust controls used.

ND - no data.

NR - not reported.

[a]Recommended procedures involve preparation, installation, and removal without sanding, use of a flat-bladed wall scraper instead of equipment that would unduly shatter the tile; and not breaking the tile by hand before placing in a disposal bag.

[b]Recommended procedures involve preparation, installation, and removal without sanding the existing floor covering or the residual felt and wet-scraping the residual felt instead of dry-scraping or sweeping.

Source: Anderson, P.H., et al. (GCA Corporation). Analysis of Fiber Release from Certain Asbestos Products. Draft Final Report. Prepared for Office of Pesticides and Toxic Substances, EPA. Contract No. 68-01-5960. December 1982. 154 pp.

TABLE 4-15. EXPOSURE MONITORING RESULTS FROM REMOVAL OF ASBESTOS ROOFING PRODUCT[83]

Sample number	Sample description[a]	Duration (min)	Concentration (f/cm^3)[b]
1	Roofer #1, Day 1	380	0.036
2	Roofer #3, Day 1	371	0.012
3	Roofer #2, Day 1	373	0.016
4	Blank, Day 1	--	ND
5	Blank, Day 2	--	ND
6	Blank, Day 2	--	ND
7	Roofer #2, Day 2	305	0.010
8	Roofer #1, Day 2	329	0.016
9	Roofer #3, Day 2	334	0.006

ND = none detected.

[a]All samples are personal breathing zone samples taken on employees of Tremco's removal subcontractor, Roofing Technologies of Schenectady, NY, on May 2, 1988 (Day 1) or May 3, 1988 (Day 2).

[b]Concentration reported as total fibers, including asbestos and nonasbestos fibers, per cubic centimeter of air and calculated as an 8-hour time-weighted-average exposure.

Source: O'Leary, C.C. (Arthur D. Little, Inc.). Regulatory Implications of the Removal of Tremply 120 Roofing Material. Report submitted to Hahn Loeser and Parks (counsel to Tremco, Inc.). June 28, 1988. 8 p.

that the results probably overestimate actual exposure levels because the NIOSH PCM analytical method does not discriminate between asbestos and nonasbestos fibers and sources of nonasbestos fibers were present at the removal site.

In another study, five separate removal methods for vinyl-asbestos floor tile (VAT) were reviewed in relation to their potential to release asbestos fibers.[84] In addition, the study tried to compare analytical results using PCM as well as transmission electron microscopy (TEM). A major discrepancy between results of side-by-side samples analyzed via PCM and TEM was noted. The TEM analysis method revealed substantially more asbestos fibers in the workplace air, although sample analysis results were hampered by some project design flaws. Results are summarized in Table 4-16. Using the dry ice removal method, the area sample results were 0.05 f/cm^3 by PCM and 1.29 f/cm^3 by TEM. The hand scraping method resulted in 0.01 f/cm^3 by PCM and 0.33 f/cm^3 by TEM for area samples. The TEM analysis of area samples for the mechanical chipping method yielded 3.77 f/cm^3. Nearly all of the personal air samples and several of the area samples were flawed and could not be analyzed.

A report sponsored by the Resilient Floor Covering Institute and three manufacturers of floor covering analyzed fiber exposures to floor mechanics and supervisory personnel during floor tile removal conducted pursuant to work practices recommended by the Resilient Floor Covering Institute and by Armstrong World Industries ("Recommended Work Practices").[86] Based on a total of 21 exposures measured according to procedures specified by OSHA, the average TWA is approximately 0.031 f/cm^3. The 95-percent upper confidence limit for all removal operations is approximately 0.09 f/cm^3. Evaluation of the samples by TEM revealed that most of the fibers counted were not asbestos. The mechanics' personal monitoring results are presented in Table 4-17. These data have not been adjusted for blanks or background concentrations, nor have 8-hour TWAs been computed. This tabulation shows that (1) the TEM counts are uniformly below the PCM counts, often by a factor of 10 or more, and (2) in about a third of the cases, no asbestos at all was detected by TEM.

Congoleum Corporation conducted a sheet vinyl flooring removal according to recommended work practices to determine worker exposure table

TABLE 4-16. MEASURED AIRBORNE FIBER CONCENTRATION FROM REMOVAL OF VINYL-ASBESTOS TILE[85]

	Dry ice	Flooding	Heat	Hand scraping	Mechanical chipper
Average size of fragments (in.)	3 x 4	1/2 x 1/2	9 x 9	1/4 x 1/4	1/2 x 1/3
Personal air samples					
PCM (f/cm^3)	*	*	*	0.01	*
TEM (s/cm^3)	*	*	*	Overload	*
Area samples					
PCM (f/cm^3)	0.05	Overload	*	0.01	Overload
TEM (s/cm^3)	1.29	Overload	*	0.33	3.77

*Insufficient sampling time.

Source: DeLisle Associates Ltd. Evaluation of Alternative Removal Methods for Vinyl Asbestos Floor Tile. Kalamazoo, MI. September 1988. 22 p.

TABLE 4-17. SUMMARY OF PERSONAL MONITORING RESULTS FOR FLOOR MECHANICS DURING REMOVAL OF ASBESTOS-CONTAINING FLOOR TILES PURSUANT TO RECOMMENDED WORK PRACTICES[87]

Site No.	Concentration (f/cm^3) PCM	TEM (asbestos)	Duration (min)	Comments
1	0.036	0.003	380	
	0.011	0.0031	321	
2	0.052	<0.0032	346	No asbestos by TEM
	0.026	0.0056	348	
3	0.23	0.0144	127	
	0.091	0.0404	130	
	0.11	0.0097	132	
4	0.051	0.016	137	
	0.035	<0.018	118	No asbestos by TEM
5	0.20	0.026	101	
	0.15	<0.012	101	No asbestos by TEM
6	0.058	<0.013	79	No asbestos by TEM
	0.18	<0.017	79	No asbestos by TEM
	0.075	0.024	90	
	0.063	<0.016	88	No asbestos by TEM
	0.18	0.021	52	
	0.091	0.025	54	
7	0.023	0.019	275	
	0.33	<0.0063	272	No asbestos by TEM
8	0.093	0.0097	141	
	0.096	0.0075	157	
9	0.054	<0.0065	198	No asbestos by TEM
	0.034	<0.0064	197	No asbestos by TEM
10	0.076	0.0066	191	
	0.041	0.0065	194	

Source: Environ Corporation, Analysis of Measurements of Airborne Fibers During Removal of Resilient Floor Tiles Using Recommended Work Practices. Prepared for Resilient Floor Covering Institute and others. December 15, 1988.

levels.[88] During removal of sheet vinyl flooring from a 12-ft by 12-ft room, fiber concentrations ranged from 0.0136 f/cm^3 to 0.0256 f/cm^3 for the two mechanics removing the flooring. Eight-hour TWAs for the two mechanics were 0.0072 f/cm^3 and 0.008 f/cm^3 (See Table 4-18).

The removal of vinyl-asbestos floor tile from a school built in 1955 was the subject of a recently published study.[89] Different removal methods were evaluated to determine which method was the easiest, most economical, and safest. The work areas were sealed with polyethylene sheeting to prevent contamination of areas outside the work area. The work areas were not kept under negative pressure in order to simulate the type of air circulation that would normally be encountered by removal personnel in an unprotected environment during vinyl-asbestos tile removal. Tiles were removed using either a hand bumper or mechanical bumper and using mixtures with various ratios of water to encapsulant and water to surfactant, in addition to dry removal. Upon removal from the floor, all tiles were placed immediately in bags. Monitoring was performed prior to and following removal using aggressive sampling methods. Air sampling was also conducted during tile removal. Air samples were analyzed using both PCM and TEM. The PCM results for floor tile removal were typically 0.01 f/cm^3 or less due, according to the authors, to the small size of the fibers present. TEM results ranged from 0.015 f/cm^3 to 1.21 f/cm^3 in the work area during removal. Results from this study are presented in Table 4-19. The results presented are for dry removal of vinyl-asbestos floor tile, and removal using different mixtures of water and surfactant, and water and encapsulant.

The GCA report did not contain fiber concentration data for the removal of A/C sheet products. Fiber levels shown in Table 4-19 are those associated with A/C sheet fabricating and end use (installation) activities. Although these concentrations do not represent concentrations resulting from removal activities, they serve to illustrate the effects of applying varying levels of mechanical energy to A/C materials. Power tools increase the likelihood of fiber release because of their pulverizing effect on the material; the use of hand-operated tools does generate dust, but the particles are coarser (and settle to the ground faster) and the amount of physical energy applied is well controlled.[91] The highest levels

TABLE 4-18. SUMMARY OF PERSONAL MONITORING RESULTS FOR FLOOR MECHANICS DURING REMOVAL OF ASBESTOS-CONTAINING SHEET VINYL FLOORING PURSUANT TO RECOMMENDED WORK PRACTICES

	Concentration (f/cm^3)	Duration (min)	8-hr TWA (f/cm^3)
Mechanic 1	0.0236	78	0.0072
	0.0136	119	
Mechanic 2	0.0256	75	0.0081
	0.0166	118	

Source: Congoleum Corporation. Air Monitoring Study--Sheet Vinyl Flooring Removal, October 1988. Trenton, NJ. March 1989.

TABLE 4-19. AIRBORNE FIBER CONCENTRATIONS MEASURED DURING REMOVAL OF VINYL ASBESTOS FLOOR TILE[90]

Removal method	Fiber concentration (f/cm^3)[a]
Dry removal	
Mechanical bumper	0.32
Mechanical bumper	NA[b]
Hand bumper	NA[b]
Water and encapsulant	
5:1 ratio	0.015
15:1 ratio	0.13
30:1 ratio	0.06
Water and surfactant	
5:1 ratio	0.08
15:1 ratio	0.13
30:1 ratio	1.21

[a]Analysis by transmission electron microscopy.
[b]Sample could not be analyzed due to overloading.

Source: Crandlemere, R. W., K. P. McCarthy, and A. B. Ginsberg. Asbestos Floor Tile Removal Techniques. Asbestos Abatement. September/October:25-33. 1988.

reported were those measured under laboratory conditions. A/C sheet was subjected to different field fabricating activities in a glove box test chamber; results ranged from 1.1 f/cm^3 for scoring to 259 f/cm^3 for sawing. Because these tests were performed in a confined, nonventilated chamber resulting in fiber accumulation, these concentrations do not represent levels that would be found under actual field conditions. The GCA report contained the results of another study in which fiber concentrations ranged from 0.6 to 41 f/cm^3, with a mean of 20 f/cm^3, for activities that involved the grinding of A/C sheet. These activities were conducted outdoors with measurement done using PCM. The other studies identified in the GCA report were conducted using power tools equipped with local exhaust pickups.

A project at a military installation was conducted to determine the extent of asbestos fiber releases while using different experimental techniques to remove nonfriable asbestos cement siding.[92] The major terest was in determining the acceptability of a mechanized approach to remove asbestos/cement siding from buildings. Machine removal of asbestos/cement siding was accomplished using a forklift with a modified bucket, along the front edge of which was a steel blade. A total of 133 samples were collected for analysis by PCM to reflect airborne fiber concentrations in association with the various methodologies used to remove asbestos/cement siding. The majority of all samples collected were below the detectable limit; however, the detection limits themselves were very low for all areas sampled. Although the detection limits were somewhat higher for the personal samples, the total fibers collected on personal samples were very low. The results are summarized in Table 4-20. Of these results, the only ones of surprising interest are those for transite removal, which indicated a higher fiber concentration when removed wet or dry. The authors explained the higher results associated with transite removal by differences in the transite manufacturing process. More specifically, nonfriable transite materials are manufactured from pressed asbestos whereas asbestos fibers in asbestos/cement siding are larger and more tightly bound to the materials during the manufacturing process. The authors also noted that the techniques used for evaluating airborne fiber concentrations were those of PCM, which allows for counting of all fibers, both asbestiform and nonasbestiform. The authors thought it likely that,

TABLE 4-20. AIRBORNE FIBER CONCENTRATIONS MEASURED DURING REMOVAL OF ASBESTOS/CEMENT SIDING[93]

Site and removal procedure	Sample type	Average concentration (f/cm3)[a]
Enclosure 1		
Machine removal[b]--heavily wetted	Personal	<0.024
	Area	0.014
Hand removal--wet	Personal	<0.039
Enclosure 2		
Machine removal--mist	Personal	<0.069
	Area	<0.007
Hand removal--wet	Area	0.0043
Enclosure 3		
Machine removal--wet	Personal	0.194
	Area	0.01
Hand removal--wet	Personal	<0.09
Enclosure 4		
Machine removal--encapsulation and wet	Personal	0.017
	Area	0.01
Open-air removal		
Machine removal--wet	Personal	<0.03
	Area	<0.0006
Hand removal--wet	Personal	<0.07
	Area	<0.001
Transite removal		
Hand removal--wet	Personal	0.679
dry	Personal	3.1
Hand removal[c]	Personal	0.139
		0.0603
Hand--encapsulated	Personal	<0.153

[a]Analysis by phase contrast microscopy.
[b]Machine removal accomplished using a forklift with a modified bucket along the front edge of which was located a steel blade 5 ft long and 6 in. wide.
[c]The report did not indicate if the removal was done wet or dry.

Source: Stanley Engineering, Inc. Building 611 Demolition: Demolition Project (DERA Project No. K060K001402). Prepared for Tulsa District Corps of Engineers. July-August 1987.

because additional fibrous insulating materials were present in the form of fiberboard and mineral wool immediately behind the asbestos/cement siding, many of the fibers counted were nonasbestiform.

4.2.1.6 Control Runoff from Wetting and Showers. As a result of wetting practices at asbestos abatement operations, contractors may have to deal with excess asbestos-containing water. A concern is that contaminated runoff may, upon drying and if disturbed, result in the release of asbestos fibers to the atmosphere. Decontamination shower facilities are also a source of asbestos-contaminated wastewater. OSHA regulations [29 CFR 1926.58(j)(2)(iii)] require shower facilities, where feasible, at asbestos removal sites.

Asbestos-containing wastewater may either be collected and disposed of as asbestos waste or the water may be treated to remove asbestos fibers before discharging the water to a sewer or a stream. Shower units are typically equipped with filters to remove asbestos from the wastewater. Excess water from wetting, however, is more difficult to contain and treat. In some abatement operations, little excess water is produced. In North Carolina, for example, the experience of the Asbestos Services Program is that water is rarely observed outside the work area, and the excess water inside the work area is typically vacuumed up with a wet vacuum cleaner and disposed of along with the rest of the asbestos waste. In Region X, the opposite is true as a result of efforts to thoroughly wet asbestos. The experience in that region is that excess water from wetting is typical and water control systems are employed to collect and filter the excess water. Water control systems may include a large funnel device to collect water and feed the contaminated water, usually by gravity, to a settling chamber before discharge to a filter designed to remove particles as small as 5 μm in diameter.

4.2.1.7 Waste Handling. The careful handling and containment of asbestos-containing waste generated as part of demolition and renovation is also necessary to prevent emissions from the job site. The asbestos that has been removed or stripped must be kept wet during all subsequent handling. Asbestos waste typically is placed in bags for transport to an acceptable disposal site. Typically, 6-mil polyethylene bags are used. They should not be filled to capacity because the wet asbestos material is heavy and may cause the bag to burst. Bags are at times placed in rigid containers, such as 55-gallon drums, for additional protection. Bags must be labeled according to the OSHA requirements in 29 CFR 1910.1001 and 1926.58. Care should be taken when filled bags are moved and stored to avoid breakage and disturbance of fibers. Although not required, bags of asbestos waste should be removed daily or stored to prevent damage by vandalism.

If it is not necessary to strip friable asbestos from structural or functional members before their removal from a building structure and the asbestos is not being stripped after removal, the friable asbestos material should be kept wet, wrapped in polyethylene, and labeled for disposal.

In some instances, bagging or wrapping of all asbestos waste may be extremely time consuming and difficult (e.g., in large demolition jobs involving large amounts of asbestos waste materials). The dismantling of a power plant is an example. Other methods of preparing asbestos waste for disposal are allowable with prior approval by EPA. Bulk-handling methods might be appropriate in some instances. Such methods might entail making a slurry of all asbestos material, placing it in an excavated on-site holding pond until job completion, and pumping it into a tanker truck for disposal in a landfill. The holding pond would be filled in after removal of slurry. Such methods would require prior EPA approval. Additionally, from a practical standpoint, a landfill that will accept asbestos waste in such a form should be identified prior to job initiation because, although such dumping is not prohibited by the NESHAP, some landfills may have their own restrictions on the form in which waste is deposited into the landfill.

Proper loading and containment of waste for transport involves enclosure of waste in leak-proof containers and careful loading to prevent breakage of containers. To prevent spills of asbestos while loading and in transport, all bagged waste should be placed in individual rigid containers. At the disposal site, unbroken bags can be removed from the rigid container and the containers saved. Broken bags should be left in their rigid containers and placed in the landfill. If bags of asbestos are placed in trucks or trailers for transport without containment in rigid containers, the truck or trailer should be covered with a tarpaulin or other suitable cover to reduce fugitive emissions from any ruptured bags.

Vehicles transporting loose but nonfriable asbestos material should also cover the waste with a tarpaulin or other suitable cover.

4.2.2 Construction

In construction, operations that would be expected to release fibers into the atmosphere (e.g., cutting A/C pipe or sheet, removal of built-up roofing, and others) generally do not occur 8 hours a day, 5 days a week.[94] Potential emission sources include installation of A/C pipe, A/C sheet, A/C architectural panels, and built-up roofing.

LEV systems connected to a vacuum source are available for power grinding, sanding, cutting, and drilling tools. However, because these tools are unwieldy under field conditions, they are not used in significant numbers by the construction industry.[95] Furthermore, the effectiveness of the LEV systems is closely associated with operator techniques and the geometry of the LEV's hood. LEV's effectiveness may decline drastically if the hood is damaged, which is likely in field use of such equipment.[96] The efficiency of the vacuum unit associated with LEV depends on the vacuum filtering system. Vacuum systems are available with HEPA filters and would be expected to have high dust control efficiencies.

Field cutting tools especially designed for A/C pipe are available, which may be hand operated or driven by electric, gasoline, or pneumatic motors. A study of worker exposure to asbestos-using manual machining lathes, snap cutting equipment, a hack saw,and a tapering tool showed that worker exposure levels were below 0.5 f/cm^3.[97] These tools are already used by some contractors installing A/C pipe and result in little lost productivity compared to losses generated by a shrouded circular saw, which requires additional time and skill on the part of the employee to perform.[98]

Wet cutting is a control technique that injects water onto the contact point between the saw blade and the product being cut; however, there is no indication that this method has been used under field conditions.[99]

4.3 WASTE DISPOSAL

4.3.1 Work Practices at Disposal Sites

4.3.1.1 Covering before Compaction. The most common method of emission control at waste disposal sites is covering the waste daily with nonasbestos compacted earth. The asbestos waste deposited in a landfill should not be compacted until several inches of cover material have been pushed over the waste. This precaution prevents emissions to the air from bags of asbestos or other asbestos materials that rupture or break during compaction.

4.3.1.2 <u>Intermediate Cover</u>. There is a concern that erosion of the surfaces of waste disposal sites taking place between the time that they become inactive and the time that final covers are applied could expose asbestos deposits for possible entrainment by water or wind. However, there are no data available to indicate how frequently this might occur. An intermediate cover placed directly on top of the daily cover has been suggested as a means of preventing asbestos exposure due to surface erosion at disposal sites from the time that they become inactive until they are closed and a final cover is put in place. A 31-cm (12-in.) intermediate cover is included as a recommended procedure at §241.209-3(b) in 40 CFR 241, Guidelines for the Land Disposal of Solid Wastes. Thus, suggested thickness for an intermediate cover is 46 cm (18 in.)--31 cm (12 in.) in addition to 15 cm (6 in.) of daily cover.

4.3.1.3 <u>Final Cover</u>. When a landfill is closed, a final cover consisting of several layers of compacted earth is normally placed on the landfill surface. The usual depth of the final cover is 63.5 cm (24 in.); 46 of the 50 states have design standards for final cover and 41 of the 46 require a minimum of 63.5 cm (24 in.) of final cover.[100] On the other hand, the Office of Solid Waste (OSW) recommends a final cover of 91 cm (36 in.) of compacted nonasbestos material for final closure of an area containing asbestos waste.[101] However, in its proposal for municipal solid waste landfills [53 FR 33314], OSW left depth of final cover up to the individual States.[102] The surface of the final cover is graded to prevent pooling of water, but to prevent erosion it is recommended that the grade not exceed 2 to 4 percent[103] and that the surface be vegetated.[104] In desert areas where vegetation would be difficult to maintain, 8 to 15 cm (3 to 6 in.) of well-graded, crushed rock is recommended for placement on top of the final cover.[105]

In northern climes and at high elevations elsewhere, penetration of the frostline through the final cover into asbestos-bearing layers is a potential problem. Frost-susceptible soils have at least a small portion of particles less than about 0.05 mm diameter, and most inorganic soils containing 3 percent or more by weight of grains finer than 0.02 mm are frost-susceptible.[106] When moist soil freezes ice is formed in the voids between the soil particles, tending to move them apart. Since the path of least resistance is upward, the particles move toward the surface. This upward movement is termed "frost heave." When the soil thaws, smaller particles tend to move down and under larger particles, helping them maintain their position. This process of size segregation is called "sorting." Thus, through repeated cycles of freezing and thawing asbestos may eventually be brought to the surface.[107]

Frost penetration into asbestos-bearing layers can be prevented by applying a final cover that is deeper than the frost penetration depth. Freezing depth can be predicted through use of the modified Berggren equation[108] as follows:

$$X = \lambda \frac{48\ KnF}{L}$$

where

X = depth of freeze, ft

λ = coefficient that takes into consideration the effect of temperature changes in the soil mass

K = thermal conductivity of the soil, Btu/ft hr °F

n = conversion factor for air index to surface index, dimensionless

F = air-freezing index, degree-days

L = volumetric latent heat of fusion, Btu/ft^3.

An alternative approach is to use the empirical relationship developed by Haugen and King[109] which is:

$$Y = -6.46228 + 1.02471 \sqrt{X}$$

where

Y = frost depth, in.

X = accumulated freezing degree-days (°F) for the season.

The standard error of estimate for frost depth is 7.5 in.

Freezing degree-days for any one day equal the difference between the average daily temperature and 32 °F. Average daily temperature is the average of the daily maximum and minimum temperatures. These data are published in A Local Climatological Data Summary for each first-order weather station by the National Weather Service. The mean air freezing index is the number of freezing degree-days between the highest and lowest points on a curve of cumulative freezing degree-days versus time for one freezing season. The design air freezing index is based on the three coldest winters in the past 30 years of record.[110]

4.3.2 Temporary Storage and Waste Transfer

Asbestos waste is normally stored at the site where it was generated until a full load is accumulated. This is done to avoid unnecessary transportation costs and unnecessary tipping fees at disposal sites where, for example, tipping fees are frequently based on the hauling capacity of the vehicle and not its weight. In the case of demolition and renovation, asbestos waste is often stored in a room within the affected building.[111] Waste is also stored in on-site dumpsters or in the waste vehicle that will be used to transport the material to the disposal site.[112] Waste is typically stored for the duration of the asbestos removal project or until a full load has been accumulated. Measures used to maintain the security of the waste and the integrity of waste containers commonly include warning signs on vehicles during loading and unloading, protection of bags/drums from the weather, use of leak-tight bags/drums that are properly identified as asbestos waste, locked storage areas to prevent public access, signs warning of the presence of asbestos, periodic inspections of the storage area, and records of waste storage.

4.3.3 Transport Vehicles

4.3.3.1 Enclosures and Covers. To help prevent the release of asbestos from waste temporarily stored in vehicles as well as during transport, asbestos waste is typically placed in vehicles with enclosed carrying compartments or in vehicles that can be securely covered with a tarpaulin, such as waterproofed canvas. The use of enclosed or covered vehicles for storage and transport helps prevent damage to containers of waste as a result of exposure to the elements and the effects of wind during transport.

4.3.3.2 Decontamination of Vehicles. Waste transport vehicles may become contaminated during the hauling of asbestos-containing waste. Contaminated vehicles are a potential emission source and may contaminate other items hauled in the contaminated cargo area if not properly cleaned. Some trucking companies, military bases, and States require waste hauling vehicles to be decontaminated or to use proper precautions to prevent gross contamination of the hauling vehicle.[113,114]

One approach to avoiding the contamination of nonasbestos loads when transport vehicles are used for different purposes is to dedicate vehicles for transport of asbestos waste only. An asbestos waste hauling company in New York has such a program and operates the only licensed asbestos transfer facility in New York State.[115] At the transfer facility, each transfer is conducted by fully trained and accredited personnel. A negative air system envelops the whole facility and each transfer is filmed. Trucks are washed down after leaving the facility to remove any dust, with all wastewater filtered. Five States have been identified that have asbestos-specific decontamination requirements. These regulations typically require that the cargo area be cleaned using wet methods or HEPA-filtered vacuuming. If polyethylene sheeting has been required, most of these States specify that it is to be discarded along with contaminated cleaning materials and protective clothing at the waste disposal site.

Currently in the Congress, the House of Representatives is considering action that would regulate the transportation of solid waste. Several measures have been introduced to address backhauling. The most comprehensive appears to be H.R. 3647.[116] If passed, the bill would, among other things, require dedicated vehicles for transportation of asbestos wastes.

4.4 SPRAYING

Asbestos, in concentrations up to 80 percent, has been spray-applied to buildings, building components, and equipment and machinery for a variety of functions, including fireproofing, thermal insulation, acoustical insulation, and decorative finishes. Sprayed bituminous and resinous materials (coatings and sealants) containing asbestos are used for waterproofing of insulation exposed to the weather, as roofing compounds, for automobile undercoating, and in marine and industrial maintenance applications to provide protection from damage due to water, chemicals, corrosion, weather, and other exposures. Spraying has the advantage of covering large areas quickly and easily covering irregular surfaces or inaccessible areas.

Sprayed asbestos-containing material as it was used for fireproofing, thermal, acoustical, and decorative purposes contained asbestos, water-setting binders such as cement, and in some cases other fibers such as glass or mineral wool. The material was usually manufactured dry and delivered in bags to the spraying site. The material was then either mixed with water to form a slurry and then sprayed or blown dry through a hose and combined with a water spray at the nozzle. These spraying operations often exposed workers and the general public to emissions; as a result, many cities as well as the EPA banned the spraying of material containing more than 1 percent asbestos by weight.

Under specified circumstances, the EPA regulations allow equipment and machinery to be sprayed with material containing more than 1 percent asbestos. However, several insulation manufacturers and insulation trade associations have stated that they do not currently add asbestos to their own insulating materials and are unaware of any insulation manufacturers who do. Similarly, State and regional enforcement agencies have not reported the use of asbestos-containing spray materials. Mixtures today typically consist of rock wool, nonasbestos mineral fiber, or slag wool, and cement.

The EPA regulation permits the spraying of asbestos-containing material in which the asbestos is encapsulated with a bituminous or resinous binder. These coatings and sealants typically contain less than 15 percent asbestos and do not become friable after drying.[117] They may be sprayed with high-pressure airless spray equipment, brushed on, or troweled on. Emissions from spraying cutback asphalt and asphalt emulsions range from 0.003 f/cm^3 to 0.6 f/cm^3.[118] Ambient air concentrations measured during spraying and in proximity to the spraying operation showed the following levels:

- 0 to 0.5 f/cm^3 for weather barrier mastics
- 0 to 0.2 f/cm^3 for industrial material with epoxy-coal tar used as a binder
- 0 to 0.4 f/cm^3 for materials with polyester or vinyl latex resins used as binders.[119]

Other materials that are used for fireproofing and for acoustical and thermal insulation include perlite and vermiculite. Perlite is a highly siliceous volcanic glass that expands upon heating into a lightweight cellular particle. Vermiculite is the name given to a group of hydrated laminar minerals that are aluminum-iron magnesium silicates, resembling mica in appearance. Upon heating, vermiculite exfoliates, or expands, due to the interlaminar generation of steam. Mixed with Portland cement and water, it is used for fireproofing. When bonded with a high-alumina cement or fireclay, vermiculite is used for high-temperature insulation.

Vermiculite is mined in the United States and South Africa. Certain deposits of vermiculite mined in the United States are known to contain tremolite asbestos. The asbestos content of the ore may be as high as 30 percent by weight. However, upon beneficiation of the ore, the vermiculite product has an average asbestos content of 10 ppm.[120]

4.5 ROADWAYS

Removal of roadways is accomplished by wet-sawing sections of the pavement, breaking up the sawed sections with a back hoe, loading the debris into a truck, and recycling or disposing of the material in a landfill. Because the asbestos is encapsulated in the asphalt, potential emissions are primarily from the sawing operation. The use of wet sawing techniques suppresses dust formation.

Milling of pavement is a wet operation that suppresses dust formation. Because of the length of time since the material was used, it is likely that milling operations would not affect most of the remaining asbestos-containing pavement. By this time it would have been resurfaced, and the new surface, not containing asbestos, would bear the major part of the milling operation.

Where pavement is recycled through asphalt batching plants, the material would normally be handled in equipment served by baghouses or scrubbers for dust collection. For portable plants, the control is more likely to be a scrubber because baghouses are harder to transport. Although not designed specifically for asbestos, the asphalt plant baghouses are expected to have high efficiency for asbestos fibers. Federal particulate standards (New Source Performance Standards [NSPS]) for plants are 0.04 gr/dscf and 20 percent opacity. Emission points are controlled either by dust suppression techniques or by loading and ducting to the control device.

4.6 ENCAPSULATION

Encapsulation is a method for controlling emissions from asbestos insulation, fireproofing, acoustical material, and decorative coatings contained in buildings and other structures. Most commonly used to control fiber release from asbestos material on ceilings, encapsulation involves spraying a sealant onto the asbestos material through airless spray equipment. The sealant acts as a barrier to prevent asbestos fibers from falling out of the material. Encapsulation may be selected instead of removal for several reasons, including the following:

- Because of irregular surfaces and obstructions, the asbestos material is not very accessible.
- Initial costs may be lower than removal costs.
- The asbestos-containing material is not friable, is in good condition, and is not likely to be disturbed.

Selection of sealants should be on a job-by-job basis since the effectiveness of the sealant may be affected by the substrate to which it is being applied, as well as the configuration, dimensions, and use characteristics of the structure to which it is being applied. Sealants are typically classified as either penetrating or bridging. Penetrating sealants penetrate the asbestos material and adhere to the substrate. Bridging agents penetrate only slightly but form a tough skin over the material. They may be used individually or in combination with the bridging agent applied after the penetrating agent. Sealants should be applied at as low a nozzle pressure as possible to reduce dissemination of fibers.

Office of Toxic Substances (OTS) guidelines for encapsulation are similar to those for asbestos removal.[121,122,123] The OTS guidelines are intended primarily to prevent contamination of the building interior; in addition, the guidelines will reduce emissions to the atmosphere. When a sealant is applied, a light mist coat applied first followed by a heavier coat is recommended to reduce dispersal of loose fibers. As in removal, surfaces that could collect dust should be removed from the work area or covered with plastic sheeting. All openings and fixtures should be sealed off with plastic and double barriers of plastic sheeting constructed at entrances and exits so that the work area is always closed off by at least one barrier as workers enter or exit. Floor and wall surfaces in the work area should be protected by plastic sheeting to prevent damage by the sealant and to facilitate cleanup after the work is completed. Following encapsulation, all surfaces should be wet cleaned or vacuumed with a HEPA filter vacuum system. All plastic sheeting, tape, and other debris should be sealed in plastic bags (6-mil minimum) for disposal.

Although encapsulation often appears to be less costly and take less time than removal, it has several limitations and disadvantages:

- Since the asbestos is not removed, the source of contamination remains and requires periodic monitoring for damage.
- The asbestos will eventually have to be removed, which will be more difficult due to the sealant; wetting may not be possible.
- It should not be used in areas where damage is likely from physical contact or water, nor should it be used on fluffy asbestos material.
- If applied to material that does not adhere to the substrate, the sealant may cause delamination.
- Repair to damaged or deteriorated encapsulated surfaces will likely be required.

Data on airborne concentrations during encapsulation are available for work area activities. Sawyer and Spooner[124] reported a mean concentration for 15 samples of 0.0 f/cm^3 by phase contrast microscopy in an encapsulation work area. They reported that one air sample that produced a zero count by optical microscopy was 7 x 10^3 ng/m^3 by TEM, indicating the release of small particles by spray contact disturbance. Using a conversion factor of 30 f/ng,[125] 7 x 10^3 ng/m^3 equals about 210,000 f/m^3 or 0.2 f/cm^3. Another EPA study of encapsulants reported work area asbestos concentrations (by TEM) of 6.4×10^7 f/m^3 (64 f/cm^3) during application of the first coat of sealant and 6.8×10^6 f/m^3 during application of the second coat.[126] The background level in the work area prior to encapsulation was 8.5×10^4 f/m^3 (0.085 f/cm^3).

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5.0 MODEL PLANTS AND REGULATORY ALTERNATIVES

This chapter describes model plants and regulatory alternatives considered by the U.S. Environmental Protection Agency (EPA) to control asbestos emissions. The model plants and regulatory alternatives were developed to serve as a basis for estimating the environmental, economic, and energy impacts of revisions to the national emission standard for asbestos.

Model plants for demolition and renovation, milling, manufacturing, fabricating, and waste disposal are presented in Section 5.1. Section 5.2 presents regulatory alternatives being considered for each source category.

5.1 MODEL PLANTS

Model plants are presented in this section. Information on emission sources (e.g., ore drying and bag opening) for specific source categories are discussed in Chapter 3. The milling, manufacturing, and fabricating model plants presented in this section include data on typical air pollution control equipment currently in use. Air pollution control equipment for these model plants consists of pulse-jet cleaned baghouses containing felted polyester bags with an air-to-cloth ratio of 4 to 1. Current controls required in demolition and renovation include wetting, placing asbestos in leak-tight containers, and disposal in landfills. Alternative controls to be analyzed are presented in Section 5.2.

Model plants were developed for demolition and renovation; asbestos milling, manufacturing, and fabricating; and asbestos waste disposal. Models were not developed for manufacturers of asbestos shotgun shell wads or spraying (currently covered by the national emission standard for hazardous air pollutants [NESHAP]) because of the low or discontinued use of asbestos in these applications. In the context of demolition and renovation,* model plants represent structures that are to be renovated or

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*Renovation includes maintenance and repair.

demolished and that may be subject to a proposed revision of the standard. The sizes of the model facilities and the locations of asbestos in the models are considered representative of actual structures that will be demolished or renovated, although the quantity of asbestos in the models is probably more than the amount actually present in such structures. Model plants for asbestos mills, asbestos product manufacturers, and asbestos product fabricators represent emission sources and structures at the industrial site, including on-site waste disposal facilities. For waste disposal sites, model plants represent off-site landfills, which are owned and operated by someone other than the generator of asbestos waste.

The models presented in this chapter represent a "base case" for comparing the cost, economic, energy, and environmental impacts of regulatory alternatives. Selection of model plants is based on a review of published information and discussions with demolition contractors, asbestos industry representatives, waste management facility representatives, and Federal and State Government officials responsible for enforcing NESHAPs and for asbestos removal programs.

Model demolitions and/or renovations were developed for each of the following categories:

- Educational buildings (5.1.1.1)
- Nonhousekeeping residential buildings (5.1.1.2)
- Stores, mercantile, and other commercial buildings (5.1.1.3)
- Multiunit dwellings (5.1.1.4)
- Petroleum refinery/petrochemical plants (5.1.1.5)
- Electric utilities (5.1.1.6)
- Industrial buildings (5.1.1.7)
- Single-unit dwellings (5.1.1.8)
- Ships (5.1.1.9)
- Office buildings (5.1.1.10)
- Hospitals and institutions (5.1.1.11)
- Sub-threshold structure (5.1.1.12)
- Structures containing nonfriable asbestos materials (5.1.1.13)

In all of these models, waste disposal is assumed to be accomplished by hauling all debris to a NESHAP waste disposal site.

Model plants were developed for the following asbestos milling, manufacturing, and fabricating facilities:

- Milling (5.1.2)
- Paper manufacturing (5.1.3.1)
- Friction materials manufacturing (5.1.3.2)
- Asbestos/cement (A/C) products manufacturing (5.1.3.3)
- Vinyl/asbestos (V/A) floor tile manufacturing (5.1.3.4)
- Asbestos-reinforced plastics manufacturing (5.1.3.5)
- Coatings and sealants manufacturing (5.1.3.6)
- Gaskets and packings manufacturing (5.1.3.7)
- Asbestos textiles manufacturing (5.1.3.8)
- Chlorine manufacturing (5.1.3.9)
- Asphalt concrete manufacturing (5.1.3.10)
- Fabricating processes (5.1.4)

Model plants also were developed for asbestos waste disposal sites (5.1.5).

5.1.1 Demolition and Renovation

5.1.1.1 Educational Buildings. Educational buildings house academic or technical instruction and include schools (elementary, junior high, and senior high), colleges or universities, vocational schools, libraries, and museums. Schools were selected to represent educational buildings.

Elementary schools, junior high schools, and high schools are commonly housed in low-rise buildings that may contain any or all of the following facilities:

- Classrooms (including industrial arts room and laboratories)
- Cafeteria and kitchen
- Auditorium
- Gymnasium
- Swimming pool
- Offices
- Teachers' lounge
- Boiler room
- Library

School buildings often contain nonfriable asbestos materials in ceiling tiles, floor tiles, laboratory counter tops, A/C pipes, and other materials. Friable asbestos materials were often used as a fire-protective coating on structural steel frames; as a decorative and acoustical finish on walls and ceilings; and as thermal insulation on boilers, heaters, steam pipes, and hot water pipes.

Three sizes of schools were selected as representative of schools containing asbestos material. The first school is a small, one-story school with a total floor area of 4,013 m^2 (43,200 ft^2). The second school is a medium-sized school consisting of three buildings: a two-story main building containing 9,490 m^2 (103,000 ft^2) of floor area, a one-story cafeteria 752 m^2 (8,100 ft^2) in area, and a 1,115-m^2 (11,700-ft^2) gymnasium. The third is a large school consisting of three buildings: a three-story main building containing 21,089 m^2 (227,000 ft^2) of floor area (plus a 2,044-m^2 [22,000-ft^2] basement), a one-story cafeteria containing 1,672 m^2 (18,000 ft^2) of floor area, and a one-story gymnasium containing 2,415 m^2 (26,000 ft^2) of floor area. Tables 5-1, 5-2, and 5-3 show asbestos-containing materials in the small, medium, and large schools, respectively.

Models were developed both for renovation and demolition of these school buildings. Three models were developed to represent the renovation of small, medium, and large schools (see Table 5-4). In all three school renovation models, renovation will consist of removal of the entire ceiling, which is covered with 1.3 cm (0.5 in.) of friable asbestos material. In all school renovation models, renovation will consist of scraping the friable asbestos material from the gypsum ceilings, dropping and disposing of the ceiling, replacing the ceiling, and spraying on a nonasbestos-containing material.

Models developed for the demolition of the schools give the amount of asbestos that must be removed prior to wrecking (see Table 5-5). Demolition will be carried out with a front-end loader for the small school and by ball and clam and front-end loader for the medium school. The large school will be demolished by ball and clam.

In the school models and in all subsequent demolition and renovation models, the amount of asbestos waste generated is three times the amount of inplace asbestos.

TABLE 5-1. ASBESTOS MATERIALS IN SMALL SCHOOL

Location of asbestos	Amount of asbestos	Type and thickness of asbestos
Boiler	9.3 m^2 (100 ft^2)	6.4-cm (2.5-in.) trowelled-on material
Steam piping Exposed 6.4-cm (2.5-in.)	30.5 m (100 ft)	2.5-cm (1-in.) premolded insulation
Concealed 1.9-cm (0.75-in.)	457 m (1,500 ft)	2.5-cm (1-in.) premolded insulation
Hot water piping Concealed 5-cm (2-in.)	61 m (200 ft)	0.64-cm (0.25-in.) corrugated paper
Concealed 2.5-cm (1-in.)	32.5 (350 ft)	0.64-cm (0.25-in.) corrugated paper
Ceiling	4,013 m^2 (43,200 ft^2)	1.27-cm (0.5-in.) sprayed-on material

TABLE 5-2. ASBESTOS MATERIALS IN MEDIUM SCHOOL

Location of asbestos	Amount of asbestos-containing material	Type and thickness of asbestos
Main building		
Boilers (2)	42 m^2 (450 ft^2)	5-cm (2-in.) premolded block
Steam piping Exposed 7.6-cm (3-in.)	20 m (65 ft)	2.5-cm (1-in.) premolded insulation
Concealed 5-cm (2-in.)	165 m (540 ft)	2.5-cm (1-in.) premolded insulation
Concealed 2.5-cm (1-in.)	549 (1,800 ft)	2.5-cm (1-in.) premolded insulation
Hot water piping Concealed 5-cm (2-in.)	110 m (360 ft)	0.6-cm (0.25-in.) corrugated paper
Concealed 2.5-cm (1-in.)	14 m (45 ft)	0.6-cm (0.25-in.) corrugated paper
Structural steel 25.4-cm (10-in.) columns	488 m (1,600 ft)	6.4-cm (2.5-in.) sprayed-on material
15.2-cm (6-in.) beams	6,858 m (22,500 ft)	3.8-cm (1.5-in) sprayed-on material
Ceiling	9,490 m^2 (103,000 ft^2)	1.3-cm (0.5-in.) sprayed-on material
Cafeteria		
Boiler	4 m^2 (45 ft^2)	5-cm (2-in.) premolded insulation
Steam piping		
Exposed 5-cm (2-in.)	11 m (36 ft)	2.5-cm (1-in.) premolded insulation
Concealed 25-cm (1-in.)	41 m (135 ft)	2.5-cm (1-in.) premolded insulation

(continued)

TABLE 5-2. ASBESTOS MATERIALS IN MEDIUM SCHOOL (continued)

Location of asbestos	Amount of asbestos-containing material	Type and thickness of asbestos
Ceiling	752 m^2 (8,100 ft^2)	1.3-cm (0.5-in.) sprayed-on material
<u>Gymnasium</u>		
Furnace	8.4 m^2 (90 ft^2)	5-cm (2-in.) trowelled-on material
Airducts	46 m^2 (495 ft^2)	0.6-cm (0.25-in.) corrugated paper
45.7-cm (18-in.) beams	192 m (630 ft)	3.8-cm (1.5-in.) sprayed-on material
5-cm (2-in.) hot water pipe	41 m (135 ft)	0.6-cm (0.25-in.) corrugated paper

TABLE 5-3. ASBESTOS MATERIALS IN LARGE SCHOOL

Location of asbestos	Amount of asbestos	Type and thickness of asbestos
Main building		
Boilers (2)	93 m^2 (1,000 ft^2)	7.6-cm (3-in.) trowelled-on material
Steam piping Exposed 7.6-cm (3-in.)	42.7 m (140 ft)	2.5-cm (1-in.) premolded insulation
Concealed 5-cm (2-in.)	366 m (1,200 ft)	2.5-cm (1-in.) premolded insulation
Concealed 2.5-cm (1-in.)	1,219 m (4,000 ft)	2.5-cm (1-in.) premolded insulation
Hot water piping Concealed 5-cm (2-in.)	244 m (800 ft)	0.6-cm (0.25-in.) corrugated paper
Concealed 2.5-cm (1-in.)	30.5 m (100 ft)	0.6-cm (0.25-in.) corrugated paper
Structural steel 25.4-cm (10-in.) columns	1,067 m (3,500 ft)	6.4-cm (2.5-in.) sprayed-on material
15.2-cm (6-in.) beams	15,240 m (50,000 ft)	3.8-cm (1.5-in) sprayed-on material
Ceiling	21,089 m^2 (227,000 ft^2)	1.3-cm (0.5-in.) sprayed-on material
Cafeteria		
Boiler	9.3 m^2 (100 ft^2)	6.4-cm (2.5 in.) trowelled-on material
Steam piping Exposed 2-in.	24.4 m (80 ft)	2.5-cm (1-in.) premolded insulation

(continued)

TABLE 5-3. ASBESTOS MATERIALS IN LARGE SCHOOL (continued)

Location of asbestos	Amount of asbestos	Type and thickness of asbestos
Concealed 1-in.	91.4 m (300 ft)	2.5-cm (1-in.) premolded insulation
Ceiling	1,672 m^2 (18,000 ft^2)	1.3-cm (0.5-in.) sprayed-on material
<u>Gymnasium</u>		
Furnace	18.6 m^2 (200 ft^2)	6.4-cm (2.5-in.) trowelled-on material
Air ducts	102 m^2 (1,100 ft^2)	0.6-cm (0.25-in.) corrugated paper
45.7-cm (18-in.) beams	427 m (1,400 ft)	3.8-cm (1.5-in.) sprayed-on material
5-cm (2-in.) hot water pipe	91.4 m (300 ft)	0.6-cm (0.25-in.) corrugated paper

TABLE 5-4. MODEL PARAMETERS FOR SCHOOL RENOVATIONS

Small school model	
Building size	4,013 m^2 (43,200 ft^2)
Asbestos removed	
Ceiling	51 m^3 (1,800 ft^3)
Asbestos waste generated	153 m^3 (200 yd^3)
Medium school model	
Building size	11,408 m^2 (122,800 ft^2)
Asbestos removed	
Ceiling	131 m^3 (4,631 ft^3)
Asbestos waste generated	393 m^3 (514 yd^3)
Large school model	
Building size	25,176 m^2 (271,000 ft^2)
Asbestos removed	
Ceiling	289 m^3 (10,208 ft^3)
Asbestos waste generated	867 m^3 (1,135 yd^3)

TABLE 5-5. MODEL PARAMETERS FOR SCHOOL DEMOLITIONS

Small school model	
Building area	4,013 m^2 (43,200 ft^2)
Asbestos removed	
Boilers	0.6 m^3 (21 ft^3)
Ceiling	51 m^3 (1,800 ft^3)
Pipes	0.9 m^3 (30.7 ft^3)
Asbestos waste generated	158 m^3 (207 yd^3)
Medium school model	
Building area	11,408 m^2 (122,800 ft^2)
Asbestos removed	
Ceiling	131 m^3 (4,629 ft^3)
Boilers and furnaces	3 m^3 (98 ft^3)
Pipes and ducts	2 m^3 (63 ft^3)
Structural steel	235 m^3 (8,295 ft^3)
Asbestos waste generated	1,113 m^3 (1,457 yd^3)
Large school model	
Building area	25,176 m^2 (271,000 ft^2)
Asbestos removed	
Ceiling	289 m^3 (10,208 ft^3)
Boilers and furnaces	9 m^3 (312 ft^3)
Pipes and ducts	9 m^3 (320 ft^3)
Structural steel	523 m^3 (18,482 ft^3)
Asbestos waste generated	2,490 m^3 (3,259 yd^3)

5.1.1.2 Nonhousekeeping Residential Buildings. Nonhousekeeping residential structures refer to buildings offering multiple accommodations for long-, or short-term residents and include hotels, motels, dormitories, fraternity and sorority houses, and similar facilities. Hotels are an example of nonresidential housekeeping buildings. They offer lodging and typically meals, entertainment, and various personal services to the public. Most hotels are multistory, steel-frame buildings that contain, in addition to lodging facilities, a kitchen, restaurant, bar, ballroom or auditorium, meeting rooms, registration desk and offices, shops, and mechanical area.

Asbestos was used in the hotels for fireproofing of steel frames; for thermal insulation on boilers, steam piping, valves, and fittings; for thermal insulation of hot water piping; and for acoustical insulation on ceilings.

Two models, a small and a large hotel, were developed to represent the demolition and renovation of hotels. The first is a large, 396-room, 12-story structure and the second is a small, 96-room, five-story structure. Both model hotels are of brick construction with steel frames.

The large hotel model is approximately 39.5 m (130 ft) high and has a floor area of 1,712 m^2 (18,432 ft^2) on each story. The hotel has a basement containing two boilers and other mechanical equipment. Table 5-6 lists the asbestos materials in the hotel. Model parameters for the demolition of the large hotel are given in Table 5-7. Demolition will be by any of three methods: implosion, ball and clam, or floor by floor.

Renovation of the large hotel will consist of removing the 348 m^2 (3,750 ft^2) of asbestos-containing material on ceilings, replacing that material with a nonasbestos material, and replacing the existing asbestos insulation on 110 m (360 ft) of exposed steam piping. Model parameters for the large hotel renovation are given in Table 5-8. The small hotel is approximately 18.3 m (60 ft) high. The area of the ground floor is approximately 2,694 m^2 (29,000 ft^2), and the area of floors two through five is 936 m^2 (10,080 ft^2) per floor. The hotel has a basement containing two boilers and other equipment.

The asbestos material in the small hotel is shown in Table 5-9. Model

TABLE 5-6. ASBESTOS MATERIALS IN LARGE HOTEL

Location of asbestos	Amount of asbestos	Type and thickness of asbestos
Boilers (2)	80 m^2 (860 ft^2)	7.6-cm (3-in.) trowelled-on material
Steam piping		
Exposed 7.6-cm (3-in.)	110 m (360 ft)	2.5-cm (1-in) premolded insulation
Concealed 5-cm (2-in.)	152 m (500 ft)	2.5-cm (1-in.) premolded insulation
Concealed 2.5-cm (1-in.)	792 m (2,600 ft)	2.5-cm (1-in.) premolded insulation
Hot water piping		
Concealed 5-cm (2-in.)	262 m (860 ft)	2.5-cm (1-in.) premolded insulation
Concealed 2.5-cm (1-in.)	792 m (2,600 ft)	2.5-cm (1-in.) premolded insulation
Structural steel		
30.5-cm (12-in.) columns	914 m (3,000 ft)	7.6-cm (3-in.) trowelled-on material
15.2-cm (6-in.) beams	13,716 m (45,000 ft)	3.8-cm (1.5-in.) trowelled-on material
Ceiling	348 m^2 (3,750 ft^2)	2.5-cm (1-in.) sprayed-on material

TABLE 5-7. MODEL PARAMETERS FOR DEMOLITION OF LARGE HOTEL

Building area	20,549 m^2 (221,184 ft^2)
Asbestos removed	
Boilers	6.1 m^3 (215 ft^3)
Pipes	9.9 m^3 (348 ft^3)
Structural steel	471 m^3 (16,625 ft^3)
Ceiling	8.7 m^3 (308 ft^3)
Asbestos waste generated	1,487 m^3 (1,946 yd^3)

TABLE 5-8. MODEL PARAMETERS FOR RENOVATION OF LARGE HOTEL

Building area	20,549 m^2 (221,184 ft^2)
Asbestos removed	
Ceiling	9 m^3 (313 ft^3)
Pipes	1 m^3 (30 ft^3)
Asbestos waste generated	30 m^3 (39 yd^3)

TABLE 5-9. ASBESTOS MATERIALS IN SMALL HOTEL

Location of asbestos	Amount of asbestos	Type and thickness of asbestos
Boilers	41 m^2 (440 ft^2)	7.6-cm (3-in.) trowelled-on material
Steam piping		
Exposed 3-in.	36.6 m (120 ft)	2.5-cm (1-in) premolded insulation
Concealed 2-in.	51.8 m (170 ft)	2.5-cm (1-in.) premolded insulation
Concealed 1-in.	274 m (900 ft)	2.5-cm (1-in.) premolded insulation
Hot water piping		
Concealed 2-in.	88.4 m (290 ft)	2.5-cm (1-in.) premolded insulation
Concealed 1-in.	274 m (900 ft)	2.5-cm (1-in.) premolded insulation
Ceiling	223 m^2 (2,400 ft^2)	2.5-cm (1-in.) sprayed-on material

parameters for the demolition of the small hotel are given in Table 5-10. Demolition will be by either ball and clam or floor by floor.

Renovation of the small hotel will consist of replacing the 223 m^2 (2,400 ft^2) of asbestos-containing materials on ceilings and replacing the existing asbestos insulation on 36.6 m (120 ft) of exposed 7.6-cm (3-in.) steam piping. Model parameters for the small hotel renovation are given in Table 5-11.

5.1.1.3 <u>Stores, Mercantile, and Other Commercial Buildings</u>. A small grocery and a medium department store were selected to represent this class of buildings.

5.1.1.3.1 <u>Grocery</u>. Grocery stores sell staple foodstuffs, household supplies, meats, produce, and dairy products. They are typically housed in single-story buildings that may have a basement mechanical room. Asbestos was used in grocery stores as thermal insulation on heaters, boilers, and piping systems.

The model grocery is contained in a single-story brick building with a floor area of 260 m^2 (2,800 ft^2). The building has a partial basement that contains a boiler and other mechanical equipment. Table 5-12 shows asbestos materials that the grocery contains.

Models were developed to represent the demolition and renovation of a small grocery. Demolition will be carried out by a front-end loader. Table 5-13 presents model parameters for the grocery demolition. Renovation of the model grocery will consist of replacing the asbestos insulation on the boiler, boiler stack, and exposed steam pipe with a nonasbestos insulation. Table 5-14 presents model parameters for the grocery renovation.

5.1.1.3.2 <u>Department store</u>. Department stores sell a wide variety of goods arranged in several departments and range in size from one- and two-story buildings to buildings of five stories or more. Asbestos materials may be found in decorative and acoustical ceiling treatments, in thermal insulation on boilers and piping, and in fire-protective coatings on structural steel.

Models were developed to represent the demolition and renovation of medium-sized department stores. The department store is contained in a two-story brick building with a reinforced concrete frame. The building also has a basement that houses a boiler and other mechanical equipment. The

TABLE 5-10. MODEL PARAMETERS FOR DEMOLITION OF SMALL HOTEL

Building area	6,440 m^2 (69,320 ft^2)
Asbestos removed	
Boilers	3.1 m^3 (110 ft^3)
Pipes	5.2 m^3 (185 ft^3)
Structural steel	157 m^3 (5,542 ft^3)
Ceiling	5.7 m^3 (200 ft^3)
Asbestos waste generated	513 m^3 (671 yd^3)

TABLE 5-11. MODEL PARAMETERS FOR RENOVATION OF SMALL HOTEL

Building area	6,440 m^2 (69,320 ft^2)
Asbestos removed	
Ceiling	5.7 m^3 (200 ft^3)
Pipes	0.3 m^3 (10 ft^3)
Asbestos waste generated	18 m^3 (24 yd^3)

TABLE 5-12. ASBESTOS MATERIALS IN SMALL GROCERY

Location of asbestos	Amount of asbestos	Type and thickness of asbestos
Boilers	9.3 m^2 (100 ft^2)	7.6-cm (3-in.) trowelled-on material
Boiler stack	3.7 m^2 (40 ft^2)	3.8-cm (1.5-in.) premolded insulation
Steam piping		
Exposed 5-cm (2-in.)	21.3 m (70 ft)	2.5-cm (1-in) premolded insulation
Concealed 2.5-cm (1-in.)	30.5 m (100 ft)	2.5-cm (1-in.) premolded insulation
Hot water piping		
Concealed 2.5-cm (1-in.)	12.2 m (40 ft)	2.5-cm (1-in.) premolded insulation

TABLE 5-13. MODEL PARAMETERS FOR DEMOLITION OF SMALL GROCERY

Building area	260 m^2 (2,800 ft^2)
Asbestos removed	
Boiler	0.7 m^3 (25 ft^3)
Stack	0.1 m^3 (5 ft^3)
Piping	0.3 m^3 (11 ft^3)
Asbestos waste generated	3 m^3 (4 yd^3)

TABLE 5-14. MODEL PARAMETERS FOR RENOVATION OF SMALL GROCERY

Building area	260 m^2 (2,800 ft^2)
Asbestos removed	
Boiler	0.7 m^3 (25 ft^3)
Stack	0.1 m^3 (5 ft^3)
Pipe	0.1 m^3 (3 ft^3)
Asbestos waste generated	3 m^3 (4 yd^3)

basement and each aboveground story have a floor area of 2,035 m^2 (21,900 ft^2). Table 5-15 shows the asbestos materials in the department store.

Demolition will be by either ball and clam or floor-by-floor demolition. Table 5-16 presents model parameters for demolition of the medium-sized department store.

Renovation of the model department store will consist of replacing the existing boiler and the thermal insulation on all exposed steam piping. All thermal insulation will be removed from the boiler before it is dismantled and removed. Table 5-17 presents model parameters for the department store renovation.

5.1.1.4 Multiunit Dwellings. A small and a medium apartment building were selected to represent multiunit dwellings. The small apartment building is a five-family apartment building and the medium apartment is a 50-family apartment building.

The five-family apartment building is a low-rise structure of wood frame construction. It is a three-story structure with a partial basement. Each story has a floor area of 232 m^2 (2,500 ft^2), and the basement has a floor area of 69.7 m^2 (750 ft^2). A boiler is located in the basement. Asbestos was used as decorative and acoustical ceiling treatments and as thermal insulation on boilers and steam piping. Table 5-18 shows the asbestos material in the small apartment building.

Models were developed to represent both the demolition and renovation of a five-family apartment building. The apartment model is to be demolished by either of two methods: ball and clam or floor by floor. All asbestos materials must be removed prior to demolition. Table 5-19 gives model parameters for the demolition of the small apartment building. In the renovation model, the decorative ceiling coating is to be replaced for the entire building. Table 5-20 presents model parameters for renovation of the small apartment building.

The 50-family apartment building is a 10-story building of steel frame construction. The building has a basement housing the heating system and other equipment. Each story has a floor area of 464.5 m^2 (5,000 ft^2). Asbestos was used as decorative and acoustical ceiling treatments, thermal insulation on boilers and steam piping, and fireproofing on steel columns and beams. Table 5-21 shows the asbestos material in the 50-family apartment building.

TABLE 5-15. ASBESTOS MATERIALS IN MEDIUM DEPARTMENT STORE

Location of asbestos	Amount of asbestos	Type and thickness of asbestos
Boilers	9.3 m^2 (100 ft^2)	7.6-cm (3-in.) trowelled-on material
Stack	5.6 m^2 (60 ft^2)	3.8-cm (1.5-in.) trowelled-on material
Steam piping		
Exposed 5-cm (2-in.)	57.9 m (190 ft)	5-cm (2-in) premolded insulation
Concealed 2.5-cm (1-in.)	183 m (600 ft)	5-cm (2-in.) premolded material

TABLE 5-16. MODEL PARAMETERS FOR DEMOLITION OF A MEDIUM DEPARTMENT STORE

Building area	6,104 m^2 (65,700 ft^2)
Asbestos removed	
Boiler	0.7 m^3 (25 ft^3)
Stack	0.2 m^3 (7.5 ft^3)
Piping	1.0 m^3 (36 ft^3)
Asbestos waste generated	6 m^3 (8 yd^3)

TABLE 5-17. MODEL PARAMETERS FOR RENOVATION OF A MEDIUM DEPARTMENT STORE

Building area	6,104 m^2 (65,700 ft^2)
Asbestos removed	
Boiler	0.7 m^3 (25 ft^3)
Piping	0.3 m^3 (10.6 ft^3)
Asbestos waste generated	3 m^3 (4 yd^3)

TABLE 5-18. ASBESTOS MATERIALS IN SMALL, FIVE-FAMILY APARTMENT BUILDING

Location of asbestos	Amount of asbestos	Type and thickness of asbestos
Boiler	7.9 m^2 (85 ft^2)	5-cm (2-in.) trowelled-on material
Stack	4.6 m^2 (50 ft^2)	5-cm (2-in.) trowelled-on material
Steam piping		
Exposed 5-cm (2-in.)	42.7 m (140 ft)	5-cm (2-in) premolded insulation
Concealed 2.5-cm (1-in.)	64 m (210 ft)	5-cm (2-in.) premolded insulation
Ceiling	697 m^2 (7,500 ft^2)	0.6-cm (0.25-in.) sprayed-on material

TABLE 5-19. MODEL PARAMETERS FOR DEMOLITION OF A SMALL, FIVE-FAMILY APARTMENT BUILDING

Building area	766 m^2 (8,250 ft^2)
Asbestos removed	
Boiler	0.4 m^3 (14.2 ft^3)
Stack	0.2 m^3 (8.3 ft^3)
Piping	0.5 m^3 (16.6 ft^3)
Ceiling	4.4 m^3 (156 ft^3)
Asbestos waste generated	17 m^3 (22 yd^3)

TABLE 5-20. MODEL PARAMETERS FOR RENOVATION OF SMALL, FIVE-FAMILY APARTMENT BUILDING

Building area	766 m^2 (8,250 ft^2)
Asbestos removed	
Ceiling	4.4 m^3 (156 ft^3)
Asbestos waste generated	13 m^3 (17 yd^3)

TABLE 5-21. ASBESTOS MATERIALS IN MEDIUM, 50-FAMILY APARTMENT BUILDING

Location of asbestos	Amount of asbestos	Type and thickness of asbestos
Boiler	52.7 m^2 (567 ft^2)	5-cm (2-in.) sprayed-on material
Stack	15.8 m^2 (170 ft^2)	5-cm (2-in.) sprayed-on material
Steam piping		
Exposed 5-cm (2-in.)	85.3 m (280 ft)	5-cm (2-in) premolded insulation
Concealed 2.5-cm (1-in.)	426.7 m (1,400 ft)	5-cm (2-in.) premolded insulation
Ceiling	4,645 m^2 (50,000 ft^2)	0.6-cm (0.25-in.) sprayed-on material
Structural steel		
30.5-cm (12-in.) columns	670.6 m (2,200 ft)	7.6-cm (3-in.) sprayed-on material
15.2-cm (6-in.) beams	2,159.2 m (7,084 ft)	3.8-cm (1.5-in.) sprayed-on material

Models were developed for the demolition and renovation of the medium apartment building. The apartment building will be demolished by implosion, ball and clam, or floor by floor. Table 5-22 gives model parameters for demolition of the apartment building. For the renovation model, the asbestos ceiling covering will be removed and replaced with nonasbestos materials. Table 5-23 presents model parameters for renovating the medium apartment building.

5.1.1.5 <u>Petroleum Refinery/Petrochemical Plants</u>. Petroleum refineries were selected to represent this class of structure. Refineries separate and convert crude oil and intermediates to produce a variety of fuels, lubricants, asphalts, road oils, and feedstock for other processors; e.g., the petrochemical industry. Asbestos was used extensively as thermal insulation on equipment and pipes to help maintain high-process temperatures and high-fluid temperatures in piping.

Models were developed to represent the demolition and renovation of small- and intermediate-capacity refineries.

The small-capacity refinery processes approximately 50,000 barrels of crude oil per day. Refinery processes include the following:

- Atmospheric and vacuum distillation of crude
- Fluid catalytic cracking
- HF alkylation/gasoline sweetening
- Gas concentration/sulfur recovery
- Gasoline fractionation
- Aromatics extraction
- Catalytic reforming.

The refinery has 186 pumps and 17 compressors in hydrocarbon service and 29 process heaters and boilers. It has 70 process vessels, 50 storage tanks, and about 900,000 ft of piping. Asbestos materials in the small refinery are shown in Table 5-24; 10 percent of the pumps, 50 percent of the tanks and vessels, and 40 percent of the piping are insulated with asbestos material.

The intermediate-capacity refinery processes approximately 200,000 barrels of crude oil per day and consists of the following processes:

- Atmospheric and vacuum distillation of crude
- Solvent decarbonizing
- Sourwater oxidizing
- Aromatics extraction
- Thermal hydrodealkylation
- Naphtha desulfurizing

TABLE 5-22. MODEL PARAMETERS FOR DEMOLITION OF MEDIUM, 50-FAMILY APARTMENT BUILDING

Building area	4,645 m^2 (50,000 ft^2)
Asbestos removed	
Boiler	2.7 m^3 (94.5 ft^3)
Stack	0.8 m^3 (28.3 ft^3)
Piping	2.4 m^3 (85.5 ft^3)
Ceiling	29.5 m^3 (1,041 ft^3)
Structural steel	130.8 m^3 (4,622 ft^3)
Asbestos waste generated	499 m^3 (653 yd^3)

TABLE 5-23. MODEL PARAMETERS FOR RENOVATION OF MEDIUM, 50-FAMILY APARTMENT BUILDING

Building area	4,645 m^2 (50,000 ft^2)
Asbestos removed	
Ceiling	29.5 m^3 (1,041.7 ft^3)
Asbestos waste generated	89 m^3 (116 yd^3)

TABLE 5-24. ASBESTOS MATERIALS IN SMALL REFINERY

Location of asbestos	Amount of asbestos	Type and thickness of asbestos
Boilers (29)	409 m^2 (4,400 ft^2) (each)	7.6-cm (3-in.) trowelled-on material
Tanks and vessels (60)	186 m^2 (2,000 ft^2) (each)	7.6-cm (3-in.) premolded material
Pumps (19)	1.7 m^2 (18 ft^2) (each)	5-cm (2-in.) premolded insulation
10-cm (4-in.) piping	109,728 m (360,000 ft)	5-cm (2-in) premolded insulation

- Catalytic cracking
- Acid-gas treating
- Sulfur recovery
- Gasoline sweetening
- Fractionating
- Hydrogen manufacturing
- Alkylation
- Naphtha hydrotreating
- Catalytic reforming.

This refinery has 411 pumps and 37 compressors in hydrocarbon service and 49 process heaters and boilers. It has 290 process vessels, 200 storage tanks, and approximately 3,500,000 ft of piping. The intermediate-capacity refinery contains asbestos materials as shown in Table 5-25; 10 percent of the pumps, 50 percent of the tanks and vessels, and 40 percent of the piping are insulated with asbestos material.

Each of the refinery models is to be totally demolished by disassembly. All asbestos materials must be removed and disposed of during demolition. Table 5-26 presents model parameters for the refinery demolitions.

Each model refinery also will conduct maintenance (renovation) activities that involve asbestos removal. In both the small and medium refinery, maintenance will consist of removing 457 m (1,500 ft) of 10-cm (4-in.) diameter steam piping located aboveground. Table 5-27 presents model parameters for the maintenance activities.

5.1.1.6 Electric Utilities. Steam-electric-generating plants often used asbestos materials as thermal insulation in fossil-fuel-fired water-tube boilers and associated turbines, valves, fittings, and piping.

Models were developed to represent the demolition and renovation (maintenance) of small and medium power plants. The first model is a small, 12-MW power station. Asbestos materials in the small power plant are listed in Table 5-28. The medium power plant is a 200-MW plant and contains asbestos material as shown in Table 5-29. Complete demolition of the two power plants is to be carried out by disassembling the unit. Model parameters for the power plant demolitions are given in Tables 5-30 and 5-31.

Renovation (maintenance) will consist of the overhaul of the turbines and associated piping at each plant. In the small power plant, maintenance involves approximately 12 m (39 ft) of piping while in the medium power plant, approximately 619 m (2,030 ft) of piping will be involved in the turbine overhaul. Model parameters for the power plant maintenance activities are given in Tables 5-32 and 5-33.

TABLE 5-25. ASBESTOS MATERIALS IN MEDIUM REFINERY

Location of asbestos	Amount of asbestos	Type and thickness of asbestos
Boilers (49)	409 m^2 (4,400 ft^2) (each)	7.6-cm (3-in.) trowelled-on material
Tanks and vessels (245)	186 m^2 (2,000 ft^2) (each)	7.6-cm (3-in.) premolded material
Pumps (41)	1.7 m^2 (18 ft^2) (each)	5-cm (2-in.) premolded insulation
10-cm (4-in.) piping	426,720 m (1,400,000 ft)	5-cm (2-in.) premolded insulation

TABLE 5-26. MODEL PARAMETERS FOR REFINERY DEMOLITION

Small refinery	
Asbestos removed	
Boilers	903 m^3 (31,900 ft^3)
Tanks and vessels	850 m^3 (30,000 ft^3)
Pumps	1.6 m^3 (57 ft^3)
Piping	2,669 m^3 (94,250 ft^3)
Asbestos waste generated	13,271 m^3 (17,368 yd^3)
Medium refinery	
Asbestos removed	
Boilers	1,526 m^3 (53,900 ft^3)
Tanks and vessels	3,469 m^3 (122,500 ft^3)
Pumps	358 m^3 (123 ft^3)
Piping	10,379 m^3 (366,528 ft^3)
Asbestos waste generated	47,196 m^3 (61,767 yd^3)

TABLE 5-27. MODEL PARAMETERS FOR REFINERY MAINTENANCE

Small refinery	
Asbestos removed	
Pipes	7.4 m^3 (262 ft^3)
Asbestos waste generated	22 m^3 (29 yd^3)
Medium refinery	
Asbestos removed	
Pipes	7.4 m^3 (262 ft^3)
Asbestos waste generated	22 m^3 (29 yd^3)

TABLE 5-28. ASBESTOS MATERIALS IN SMALL, 12-MW POWER PLANT

Location of asbestos	Amount of asbestos	Type and thickness of asbestos
Boiler	74 m^2 (800 ft^2)	7.6-cm (3-in.) premolded insulation
Turbine	3 m^2 (30 ft^2)	7.6-cm (3-in.) premolded insulation
10-cm (4-in) piping	457 m (1,500 ft)	7.6-cm (3-in.) premolded insulation
Miscellaneous	19 m^2 (200 ft^2)	7.6-cm (3-in) premolded insulation

TABLE 5-29. ASBESTOS MATERIALS IN MEDIUM, 200-MW POWER PLANT

Location of asbestos	Amount of asbestos	Type and thickness of asbestos
Boiler	1,189 m^2 (12,800 ft^2)	7.6-cm (3-in.) premolded insulation
Turbine	18.6 m^2 (200 ft^2)	7.6-cm (3-in.) premolded insulation
30-cm (12-in) piping	6,096 m (20,000 ft)	7.6-cm (3-in.) premolded insulation
Miscellaneous	232 m^2 (2,500 ft^2)	7.6-cm (3-in) premolded insulation

TABLE 5-30. MODEL PARAMETERS FOR SMALL, 12-MW POWER PLANT DEMOLITION

Asbestos removed	
Boiler	5.7 m^3 (200 ft^3)
Turbine	0.2 m^3 (8 ft^3)
Pipes	10.6 m^3 (375 ft^3)
Miscellaneous	1.4 (50 ft^3)
Asbestos waste generated	54 m^3 (71 yd^3)

TABLE 5-31. MODEL PARAMETERS FOR MEDIUM, 200-MW POWER PLANT DEMOLITION

Asbestos removed	
Boiler	91 m^3 (3,200 ft^3)
Turbine	1.4 m^3 (50 ft^3)
Pipes	555 m^3 (19,600 ft^3)
Miscellaneous	18 m^3 (625 ft^3)
Asbestos waste generated	1,996 m^3 (2,573 yd^3)

TABLE 5-32. MODEL PARAMETERS FOR SMALL, 12-MW POWER PLANT MAINTENANCE

Asbestos removed	
Turbine	0.2 m^3 (8 ft^3)
Pipes	0.2 m^3 (7 ft^3)
Asbestos waste generated	1 m^3 (1 yd^3)

TABLE 5-33. MODEL PARAMETERS FOR MEDIUM, 200-MW POWER PLANT MAINTENANCE

Asbestos removed	
Turbine	1.4 m^3 (50 ft^3)
Pipes	56.2 m^3 (1,990 ft^3)
Asbestos waste generated	58 m^3 (76 yd^3)

5.1.1.7 Industrial Buildings. Industrial buildings house manufacturing and the processing or procurement of goods, merchandise, raw materials, or food. Boilers are an important part of many industrial operations. Because of the prevalence of boilers in industrial plants and because thermal insulation is used on boilers and their associated steam and hot water piping, model boilers were developed to represent the occurrence of asbestos in industrial buildings.

Models were developed to represent maintenance and demolition of a small and medium boiler in a small and medium industrial building, respectively. Boiler demolition is done in the context of demolition of the industrial building. Asbestos materials in the small and medium industrial buildings are shown in Tables 5-34 and 5-35, respectively.

Demolition of the boilers is to be carried out by dismantling and removing the boiler. All asbestos materials must be removed from the boiler, pipe, and exhaust duct before they are dismantled and removed. Table 5-36 presents model parameters for the boiler demolitions.

For the renovation or maintenance models, the boilers will be repaired, which will involve removal of asbestos on boilers, boiler stacks, and a small amount of steam piping, approximately 3 m (10 ft) in the small industrial building and 6 m (20 ft) in the medium industrial building. The asbestos on most of the steam piping is not affected. Table 5-37 presents model parameters for the boiler maintenance/repair work.

5.1.1.8 Single-Unit Dwellings. Single-unit dwellings provide basic living accommodations for a family. These dwellings normally contain cooking and dining facilities, sleeping quarters, and areas for leisure and recreational activities. They are usually one- or two-story wood frame structures and often have a partial basement furnace room.

Asbestos has been used for a wide variety of applications in private home constructions. Some applications have been common, others have been only occasional. The following list summarizes asbestos use in private homes:

- Furnace and pipe insulation
- Floor coverings (V/A floor tile and paper backing for other floor coverings)
- Roofing products (asphalt shingles, A/C shingles, and roofing felts)

TABLE 5-34. ASBESTOS MATERIALS IN SMALL INDUSTRIAL BUILDING

Location of asbestos	Amount of asbestos	Type and thickness of asbestos
Boiler	139 m^2 (1,500 ft^2)	6.4-cm (2.5-in.) layered paper and trowelled-on material
15-cm (6-in.) steam pipe	152 m (500 ft)	3-cm (1.2-in.) premolded insulation
Boiler exhaust duct	19.9 m^2 (214 ft^2)	1.3-cm (0.5-in) trowelled-on material

TABLE 5-35. ASBESTOS MATERIALS IN MEDIUM INDUSTRIAL BUILDING

Location of asbestos	Amount of asbestos	Type and thickness of asbestos
Boiler	929 m^2 (10,000 ft^2)	6.4-cm (2.5-in.) layered paper and trowelled-on material
30.5-cm (12-in.) steam pipe	456 m (1,500 ft)	3-cm (1.2-in.) premolded insulation
Boiler exhaust duct	63.2 m^2 (680 ft^2)	1.3-cm (0.5-in) trowelled-on material

TABLE 5-36. MODEL PARAMETERS FOR INDUSTRIAL BUILDING BOILER DEMOLITION

<u>Small industrial boiler</u>	
Asbestos removed	
Boiler	8.8 m^3 (312 ft^3)
Pipe	2.2 m^3 (78.5 ft^3)
Exhaust duct	34 m^3 (44 yd^3)
Asbestos waste generated	34 m^3 (44 yd^3)
<u>Medium industrial boiler</u>	
Asbestos removed	
Boiler	59 m^3 (2,083 ft^3)
Pipe	13.3 m^3 (471.2 ft^3)
Exhaust duct	0.8 m^3 (28.3 ft^3)
Asbestos waste generated	219 m^3 (287 yd^3)

TABLE 5-37. MODEL PARAMETERS FOR INDUSTRIAL BUILDING BOILER MAINTENANCE

<u>Small industrial boiler</u>	
Asbestos removed	
Boiler	8.8 m^3 (312 ft^3)
Pipe	0.1 m^3 (1.9 ft^3)
Exhaust duct	0.3 m^3 (8.9 ft^3)
Asbestos waste generated	28 m^3 (37 yd^3)
<u>Medium industrial boiler</u>	
Asbestos removed	
Boiler	59 m^3 (2,083 ft^3)
Pipe	0.2 m^3 (6.9 ft^3)
Exhaust duct	0.8 m^3 (28.3 ft^3)
Asbestos waste generated	180 m^3 (236 yd^3)

- Siding materials (A/C shingles)
- Tape joint and spackling compounds
- Wallboard (used for fireproofing between living area and attached garages)
- Textured ceiling paint
- Ceiling tile
- Wall and ceiling insulation.

Furnace and pipe insulation, tape joint and spackling compounds, A/C shingles, and textured ceiling paint were used widely in home construction and are considered friable materials. Floor coverings and asphalt roofing products also were used frequently but are not considered friable because the asbestos is bound tightly in the products and would not be released significantly during demolition. Asbestos-containing wallboard, ceiling tile, and wall and ceiling insulation were used infrequently in private home construction. All are considered friable.

Three models of single-unit dwellings were selected as representative of the class. All three have the same structure but differ in the extent to which asbestos-containing products were used in their construction. The structure for each model is a one-story wood frame building with a floor area of 120 m^2 (1,288 ft^2), a partial basement with a floor area of 20 m^2 (216 ft^2), and an attached garage with a floor area of 10.8 m^2 (116 ft^2). The quantities of asbestos products in each model are shown in Table 5-38.

Demolition of each model is to be accomplished with a bulldozer. Model parameters for the private home demolitions are presented in Table 5-39.

Renovation of each model will involve removal of different quantities of asbestos. In Model A, the asbestos insulation on the furnace is to be replaced with a nonasbestos insulation. In Model B, the asbestos furnace insulation is to be replaced and the asbestos-covered ducts are to be removed and replaced with a nonasbestos-covered ductwork. The asbestos-covered ceiling in Model C will be replaced. Model parameters for the private home renovations are presented in Table 5-40.

TABLE 5-38. ASBESTOS MATERIALS IN SINGLE-UNIT DWELLING

Location of asbestos	Amount of asbestos	Type and thickness of asbestos
Model A		
Furnace	6.7 m^2 (72 ft^2)	7.6-cm (3-in.) trowelled-on material
12.7-cm (5-in.) ducts	18.3 m (60 ft)	5-cm (3-in.) premolded insulation
Model B		
Furnace	6.7 m^2 (72 ft^2)	7.6-cm (3-in.) trowelled-on material
12.7-cm (5-in.) ducts	18.3 m (60 ft)	5-cm (2-in.) premolded insulation
Walls (interior)	10.4 m^2 (112 ft^2)	1.6-cm (0.6-in.) wallboard
Model C		
Furnace	6.7 m^2 (72 ft^2)	7.6-cm (3-in.) trowelled-on material
12.7-cm (5-in.) ducts	18.3 m (60 ft)	5-cm (2-in.) premolded insulation
Walls (exterior)	110 m^2 (1,184 ft^2)	0.6-cm (0.3-in.) A/C shingles
Ceiling	120 m^2 (1,288 ft^2)	1.3-cm (0.5-in.) sprayed-on material

TABLE 5-39. MODEL PARAMETERS FOR DEMOLITION OF SINGLE-UNIT DWELLINGS

Model A	
Asbestos removed	
Furnace	0.5 m^3 (18 ft^3)
Ducts	0.5 m^3 (18 ft^3)
Asbestos waste generated	3 m^3 (4 yd^3)
Model B	
Asbestos removed	
Furnace	0.5 m^3 (18 ft^3)
Ducts	0.5 m^3 (18 ft^3)
Walls	0.2 m^3 (6 ft^3)
Asbestos waste generated	4 m^3 (5 yd^3)
Model C	
Asbestos removed	
Furnace	0.5 m^3 (18 ft^3)
Ducts	0.5 m^3 (18 ft^3)
Exterior walls	0.7 m^3 (25 ft^3)
Ceiling	1.2 m^3 (54 ft^3)
Asbestos waste generated	9 m^3 (12 yd^3)

TABLE 5-40. MODEL PARAMETERS FOR RENOVATION OF SINGLE-UNIT DWELLINGS

Model A	
Asbestos removed	
Furnace	0.5 m^3 (18 ft^3)
Asbestos waste generated	2 m^3 (3 yd^3)
Model B	
Asbestos removed	
Furnace	0.5 m^3 (18 ft^3)
Ducts	0.5 m^3 (18 ft^3)
Asbestos waste generated	3 m^3 (4 yd^3)
Model C	
Asbestos removed	
Ceiling	1.2 m^3 (54 ft^3)
Asbestos waste generated	4 m^3 (5 yd^3)

5.1.1.9 Ships.

5.1.1.9.1 Passenger ships. Passenger ships are large vessels normally driven by steam power. They are equipped with boilers, turbines, and associated piping and equipment that require thermal insulation.

Asbestos insulation is located on steam and hot water pipes and fittings, feedwater pumps, evaporators, turbines, and condensers.

One model was developed to represent a maintenance activity on a cruise ship. Maintenance consists of the overhaul of two turbines on a 22,680-Mg (25,000-ton) cruise ship. Overhaul requires removal of asbestos insulation from turbines and related pipes, valves, and fittings. Table 5-41 shows the quantities of asbestos involved, and Table 5-42 presents model parameters for the turbine overhaul.

5.1.1.9.2 Cargo ships. Cargo ships are of many different types and classes, depending on the type of service for which they were designed. They range in length from about 152 m (500 ft) to more than 305 m (1,000 ft). When ships are retired from active service, they are placed in a reserve fleet where, from time to time, they are designated for scrap and put up for bids.

Asbestos-containing products on cargo ships consist of wallboard to cover the bulkheads in the accommodations area and of insulation on hot water and steam piping and on boilers, tanks, and machinery casings.

One model was selected to represent demolition of an average-sized cargo ship. The model cargo ship has a length of 152 m (500 ft), a beam of 18.3 m (60 ft), and a deadweight of about 9,072 Mg (10,000 ton). The model ship will be demolished by a ship-wrecking crew, who will remove all asbestos-containing material before dismantling the ship. Table 5-43 shows the quantities of asbestos materials the model cargo ship contains. Model parameters for the cargo ship demolition are given in Table 5-44.

5.1.1.10 Office Buildings. Office buildings generally provide working space for service-type organizations such as architectural, engineering, law, financial, and managerial organizations. In addition to individual offices, these buildings may also contain conference rooms, cafeterias, and support facilities such as drafting and duplicating centers.

TABLE 5-41. ASBESTOS MATERIALS IN CRUISE SHIP

Location of asbestos	Amount of asbestos	Type and thickness of asbestos
Turbines (2)	55.7 m^2 (600 ft^2)	7.6-cm (3-in.) premolded insulation
Pipes	9.3 m^2 (100 ft^2)	7.6-cm (3-in.) premolded insulation

TABLE 5-42. MODEL PARAMETERS FOR TURBINE OVERHAUL ON CRUISE SHIPS

Asbestos removed	
Turbines	4.2 m^3 (150 ft^3)
Pipes	0.7 m^3 (25 ft^3)
Asbestos waste generated	15 m^3 (20 yd^3)

TABLE 5-43. ASBESTOS MATERIALS IN CARGO SHIP

Location of asbestos	Amount of asbestos	Type and thickness of asbestos
Bulkheads	2,787 m^2 (30,000 ft^2)	0.64-cm (1/4-in.) marine board
Equipment	1,300 m^2 (14,000 ft^2)	5-cm (2-in.) trowelled-on material
Pipes	2,415 m^2 (26,000 ft^2)	5-cm (2-in.) premolded insulation

TABLE 5-44. MODEL PARAMETERS FOR DEMOLITION OF CARGO SHIPS

Asbestos removed	
Walls	18 m^3 (625 ft^3)
Equipment	66 m^3 (2,333 ft^3)
Pipes	123 m^3 (4,333 ft^3)
Asbestos waste generated	621 m^3 (813 yd^3)

Asbestos was used in office buildings as acoustical ceiling treatments, fireproofing for steel frames, and thermal insulation on boilers, furnaces, and associated pipes and ducts. Office buildings range in size from small, one-story wood frame structures to large, multistory, steel frame structures.

Models were developed to represent the demolition and renovation of small, medium, and large office buildings. The first is a small, one-story building with a steel frame and masonry veneer. The building is 3 m (10 ft) high and has a floor area of 669 m^2 (7,200 ft^2). The building has a partial basement that houses a boiler and other mechanical equipment. Table 5-45 shows the asbestos materials in the small office building and Tables 5-46 and 5-47 present model parameters for its demolition and renovation, respectively. Renovation will consist of replacement of the ceiling. Demolition will be by front-end loader.

The second office building is a medium, five-story, reinforced concrete building with a total floor area of 3,344 m^2 (36,000 ft^2) on the five aboveground stories. The model is 18.3 m (60 ft) high and contains a partial basement that houses a boiler and other mechanical equipment. Table 5-48 lists the asbestos materials contained in the model. Tables 5-49 and 5-50 present model parameters for demolition and renovation of the building. Renovation will consist of replacing the ceiling. Demolition will be by ball and clam or floor by floor.

The third office building is a large, 20-story steel frame structure with a full basement. The model is 61 m (200 ft) high and has a total floor area of 26,756 m^2 (288,000 ft^2) excluding the basement. The basement contains two boilers and other mechanical equipment. Several storage areas are also located in the basement. Table 5-51 presents the asbestos materials contained in the large office building. Tables 5-52 and 5-53 give model parameters for demolition and renovation of the building. Renovation will consist of replacing the ceiling. Demolition will be by implosion, ball and clam, or floor by floor.

5.1.1.11 <u>Hospitals and Institutions</u>. Hospitals and institutions are designed to provide overnight care for ill, injured, or otherwise disabled persons. In addition to general care rooms and wards, they have special areas set aside for emergency treatment, surgery, and other special

TABLE 5-45. ASBESTOS MATERIALS IN SMALL OFFICE BUILDINGS

Location of asbestos	Amount of asbestos	Type and thickness of asbestos
Boiler	9.3 m^2 (100 ft^2)	7.6-cm (3-in.) trowelled-on material
Boiler stack	3.7 m^2 (40 ft^2)	3.8-cm (1.5-in.) premolded insulation
Steam piping		
Exposed 5-cm (2-in.)	21.3 m (70 ft)	2.5-cm (1-in.) premolded insulation
Concealed 2.5-cm (1-in.)	66 m (250 ft)	2.5-cm (1-in.) premolded insulation
Hot water piping		
Concealed 2.5-cm (1-in.)	30.5 m (100 ft)	2.5-cm (1-in.) premolded insulation
Ceiling	669 m^2 (7,200 ft^2)	1.3-cm (0.5-in.) sprayed-on material

TABLE 5-46. MODEL PARAMETERS FOR DEMOLITION OF SMALL OFFICE BUILDING

Building area	669 m^2 (7,200 ft^2)
Asbestos removed	
Boiler	0.71 m^3 (25 ft^3)
Stack	0.14 m^3 (5 ft^3)
Piping	0.43 m^3 (15.3 ft^3)
Ceiling	8.5 m^3 (300 ft^3)
Asbestos waste generated	29 m^3 (38 yd^3)

TABLE 5-47. MODEL PARAMETERS FOR RENOVATION OF SMALL OFFICE BUILDINGS

Building area	669 m^2 (7,200 ft^2)
Asbestos removed Ceiling	8.5 m^3 (300 ft^3)
Asbestos waste generated	26 m^3 (34 yd^3)

TABLE 5-48. ASBESTOS MATERIALS IN MEDIUM OFFICE BUILDING

Location of asbestos	Amount of asbestos	Type and thickness of asbestos
Boiler	27.9 m^2 (300 ft^2)	7.6-cm (3-in.) trowelled-on material
Steam piping Exposed 7.6-cm (3-in.)	36.6 m (120 ft)	2.5-cm (1-in.) premolded insulation
Concealed 5-cm (2-in.)	30.5 m (100 ft)	2.5-cm (1-in.) premolded insulation
Concealed 2.5-cm (1-in.)	137.2 m (450 ft)	2.5-cm (1-in.) premolded insulation
Hot water piping Concealed 5-cm (2-in.)	45.7 m (150 ft)	2.5-cm (1-in.) premolded insulation
Concealed 2.5-cm (1-in.)	137.2 m (450 ft)	2.5-cm (1-in.) premolded insulation
Ceiling	3,344 m^2 (36,000 ft^2)	2.5-cm (1-in.) sprayed-on material

TABLE 5-49. MODEL PARAMETERS FOR DEMOLITION OF MEDIUM OFFICE BUILDING

Building area	3,344 m^2 (36,000 ft^2)
Asbestos removed	
Boilers	2.1 m^3 (75 ft^3)
Pipes	1.9 m^3 (66.2 ft^3)
Ceiling	84.9 m^3 (3,000 ft^3)
Asbestos waste generated	267 m^3 (349 yd^3)

TABLE 5-50. MODEL PARAMETERS FOR RENOVATION OF MEDIUM OFFICE BUILDING

Building area	3,344 m^2 (36,000 ft^2)
Asbestos removed	
Ceiling	84.9 m^3 (3,000 ft^3)
Asbestos waste generated	255 m^3 (334 yd^3)

TABLE 5-51. ASBESTOS MATERIALS IN LARGE OFFICE BUILDING

Location of asbestos	Amount of asbestos	Type and thickness of asbestos
Boiler (2)	74.3 m^2 (800 ft^2)	7.6-cm (3-in.) trowelled-on material
Steam piping Exposed 7.6-cm (3-in.)	110 m (360 ft)	2.5-cm (1-in.) premolded insulation
Concealed 5-cm (2-in.)	198 m (650 ft)	2.5-cm (1-in.) premolded insulation
Concealed 2.5-cm (1-in.)	1,006 m (3,300 ft)	2.5-cm (1-in.) premolded insulation
Hot water piping Concealed 5-cm (2-in.)	335 m (1,100 ft)	2.5-cm (1-in.) premolded insulation
Concealed 2.5-cm (1-in.)	1,006 m (3,300 ft)	2.5-cm (1-in.) premolded insulation
Structural steel 30.5-cm (12-in.) columns	1,189 m (3,900 ft)	7.6-cm (3-in.) sprayed-on material
15.2-cm (6-in.) beams	17,678 m (58,000 ft)	3.8-cm (1.5-in.) sprayed-on material
Ceiling	26,756 m^2 (288,000 ft^2)	2.5-cm (1-in.) sprayed-on material

TABLE 5-52. MODEL PARAMETERS FOR DEMOLITION OF LARGE OFFICE BUILDING

Building area	26,756 m^2 (288,000 ft^2)
Asbestos removed	
Boilers	5.7 m^3 (200 ft^3)
Pipes	12.3 m^3 (434 ft^3)
Structural steel	609 m^3 (21,500 ft^3)
Ceiling	679 m^3 (24,000 ft^3)
Asbestos waste generated	3,918 m^3 (5,128 yd^3)

TABLE 5-53. MODEL PARAMETERS FOR RENOVATION OF LARGE OFFICE BUILDING

Building area	26,756 m^2 (288,000 ft^2)
Asbestos removed	
Ceiling	679 m^3 (24,000 ft^3)
Asbestos waste generated	2,037 m^3 (2,666 yd^3)

functions. Hospitals and institutions are housed in buildings that range from small one-story structures to large, multistory structures. Asbestos was used as fireproofing on steel frames; as thermal insulation on boilers, furnaces, and piping; and as acoustical treatments on ceilings.

Models were developed to represent the demolition and renovation of small, medium, and large hospitals and institutions. The first is small, a 10-bed hospital in a one-story structure with a total floor area of 4,389 m^2 (14,400 ft^2). The hospital has a partial basement with a floor area of 74.3 m^2 (800 ft^2). A small boiler and other mechanical equipment are housed in the basement. Table 5-54 shows the amount of asbestos materials contained in the small hospital and Tables 5-55 and 5-56 present model parameters for its demolition and renovation, respectively. Demolition will be by front-end loader and renovation will consist of replacing the boiler, stack, and exposed steam piping.

The second hospital is a medium hospital with 200 beds in a three-story steel frame building. A small separate building adjacent to the main building houses two boilers and other mechanical equipment to support hospital operations. The main building is 98 m (32 ft) high and has a total floor area of 5,574 m^2 (60,000 ft^2). Table 5-57 shows the amount of asbestos materials in the medium hospital and Tables 5-58 and 5-59 present model parameters for demolition and renovation of the hospital. Demolition will be by ball and clam or floor by floor. Renovation will consist of replacing boiler, stacks, and exposed steam piping.

The third hospital is a large, 800-bed hospital in a metropolitan area. Contained in a seven-story reinforced concrete building, the hospital has a full basement that contains storage areas, two boilers, and other mechanical equipment. The building is 22 m (72 ft) high and has a total floor area of 29,357 m^2 (316,000 ft^2) in the seven aboveground stories (3,530 m^2 [38,000 ft^2] per story). Table 5-60 lists the amount of asbestos materials contained in the model and Tables 5-61 and 5-62 present model parameters for demolition and renovation of the model. Demolition will be by implosion, ball and clam, or floor by floor; renovation will consist of replacing the boilers, stacks, and exposed steam piping.

TABLE 5-54. ASBESTOS MATERIALS IN SMALL HOSPITAL

Location of asbestos	Amount of asbestos	Type and thickness of asbestos
Boiler	9.3 m^2 (100 ft^2)	7.6-cm (3-in.) trowelled-on material
Boiler stack	3.7 m^2 (40 ft^2)	3.8-cm (1.5-in.) premolded insulation
Steam piping		
Exposed 5-cm (2-in.)	21.3 m (70 ft)	2.5-cm (1-in.) premolded insulation
Concealed 2.5-cm (1-in.)	128 m (420 ft)	2.5-cm (1-in.) premolded insulation
Hot water piping		
Concealed 2.5-cm (1-in.)	183 m (600 ft)	2.5-cm (1-in.) premolded insulation
Ceiling	74.3 m^2 (800 ft^2)	1.3-cm (0.5-in.) trowelled-on material

TABLE 5-55. MODEL PARAMETERS FOR DEMOLITION OF SMALL HOSPITAL

Building area	1,338 m^2 (14,400 ft^2)
Asbestos removed	
Boiler	0.7 m^3 (25 ft^3)
Stack	0.1 m^3 (5 ft^3)
Piping	1.4 m^3 (49.1 ft^3)
Ceiling	0.9 m^3 (33.3 ft^3)
Asbestos waste generated	9 m^3 (12 yd^3)

TABLE 5-56. MODEL PARAMETERS FOR RENOVATION OF SMALL HOSPITAL

Building area	1,338 m^2 (14,400 ft^2)
Asbestos removed	
Boiler	0.71 m^3 (25 ft^3)
Stack	0.14 m^3 (5 ft^3)
Piping	0.1 m^3 (3 ft^3)
Asbestos waste generated	3 m^3 (4 yd^3)

TABLE 5-57. ASBESTOS MATERIALS IN MEDIUM HOSPITAL

Location of asbestos	Amount of asbestos	Type and thickness of asbestos
Boiler (2)	41.8 m^2 (450 ft^2)	7.6-cm (3-in.) trowelled-on material
Stacks (2)	9.3 m^2 (100 ft^2)	2.5-cm (1-in.) premolded insulation
Steam piping		
Exposed 7.6-cm (3-in.)	18.3 m (60 ft)	2.5-cm (1-in.) premolded insulation
Concealed 5-cm (2-in.)	457 m (1,500 ft)	2.5-cm (1-in.) premolded insulation
Concealed 2.5-cm (1-in.)	762 m (2,500 ft)	2.5-cm (1-in.) premolded insulation
Hot water piping		
Concealed 5-cm (2-in.)	457 m (1,500 ft)	2.5-cm (1-in.) premolded insulation
Concealed 2.5-cm (1-in.)	762 m (2,500 ft)	2.5-cm (1-in.) premolded insulation
Structural steel		
25.4-cm (10-in.) columns	2,865 m (9,400 ft)	6.4-cm (2.5-in.) sprayed-on material
15.2-cm (6-in.) beams	4,389 m (14,400 ft)	3.8-cm (1.5-in.) sprayed-on material

TABLE 5-58. MODEL PARAMETERS FOR DEMOLITION OF MEDIUM HOSPITAL

Building area	5,574 m^2 (60,000 ft^2)
Asbestos removed	
Boiler	3.2 m^3 (112 ft^3)
Stack	0.2 m^3 (8.3 ft^3)
Piping	12 m^3 (419 ft^3)
Structural steel	322 m^3 (11,380 ft^3)
Asbestos waste generated	1,012 m^3 (1,324 yd^3)

TABLE 5-59. MODEL PARAMETERS FOR RENOVATION OF MEDIUM HOSPITAL

Building area	5,574 m^2 (60,000 ft^2)
Asbestos removed	
Boiler	3.2 m^3 (112 ft^3)
Stack	0.2 m^3 (8.3 ft^3)
Piping	0.1 m^3 (3.9 ft^3)
Asbestos waste generated	11 m^3 (14 yd^3)

TABLE 5-60. ASBESTOS MATERIALS IN LARGE HOSPITAL

Location of asbestos	Amount of asbestos	Type and thickness of asbestos
Boiler (2)	83.6 m^2 (900 ft^2)	7.6-cm (3-in.) trowelled-on material
Stacks (2)	20.9 m^2 (225 ft^2)	2.5-cm (1-in.) premolded insulation
Steam piping		
Exposed 7.6-cm (3-in.)	122 m (400 ft)	2.5-cm (1-in.) premolded insulation
Concealed 5-cm (2-in.)	2,006 m (6,580 ft)	2.5-cm (1-in.) premolded insulation
Concealed 2.5-cm (1-in.)	7,315 m (24,000 ft)	2.5-cm (1-in.) premolded insulation
Hot water piping		
Exposed 5-cm (2-in.)	122 m (400 ft)	2.5-cm (1-in.) premolded insulation
Concealed 5-cm (2-in.)	2,006 m (6,580 ft)	2.5-cm (1-in.) premolded insulation
Concealed 2.5-cm (1-in.)	7,315 m (24,000 ft)	2.5-cm (1-in.) premolded insulation
Ceiling	3,530 m^2 (38,000 ft^2)	1.3-cm (0.5-in.) sprayed-on material

TABLE 5-61. MODEL PARAMETERS FOR DEMOLITION OF LARGE HOSPITAL

Building area	31,293 m^2 (316,000 ft^2)
Asbestos removed	
Boilers	6.4 m^3 (225 ft^3)
Stacks	0.5 m^3 (18.8 ft^3)
Piping	85.4 m^3 (3,015 ft^3)
Ceiling	44.8 m^3 (1,583 ft^3)
Asbestos waste generated	411 m^3 (538 yd^3)

TABLE 5-62. MODEL PARAMETERS FOR RENOVATION OF LARGE HOSPITAL

Building area	31,293 m^2 (316,000 ft^2)
Asbestos removed	
Boilers	6.4 m^3 (225 ft^3)
Stacks	0.5 m^3 (18.8 ft^3)
Piping	0.7 m^3 (26.2 ft^3)
Asbestos waste generated	23 m^3 (30 yd^3)

5.1.1.12 Sub-threshold Structure. This model represents additional buildings that would be subject to the NESHAP work practice requirements for demolitions and renovations if the present threshold amounts were deleted and all removals involving any quantity of asbestos were covered. The model includes asbestos on a furnace and on piping; the amounts are shown in Table 5-63. Parameters for demolition and renovation of the model sub-threshold structure are shown in Table 5-64.

5.1.1.13 Structures Containing Nonfriable Asbestos Materials. Model structures were developed to represent structures containing various nonfriable materials including A/C sheet, vinyl floor tile, and built-up roofing.

5.1.1.13.1 Vinyl Floor Tile. Vinyl floor tiles were used widely in most types of building construction, including residential, commercial, industrial, and institutional and were installed over various types of decking material including wood and concrete. A three-story, five-unit apartment building was selected for the model containing vinyl floor tile. Prior to demolition, the entire 7,500 ft^2 of floor tile will be manually removed. The renovation consists of manually removing 2,500 ft^2 of floor tile. Table 5-65 presents information on the model apartment containing nonfriable vinyl floor tile. The model parameters for the demolition and renovation are presented in Table 5-66.

5.1.1.13.2 A/C Sheet. Corrugated and flat A/C sheet were widely used as siding and roofing in the construction of industrial buildings. It has been estimated that the average amount of A/C siding and roofing used per industrial building construction project is 24,750 ft^2. A model was developed representing both the demolition and renovation of an industrial structure containing 24,750 ft^2 of A/C siding and roofing material. The entire 24,750 ft^2 of A/C sheet is removed by hand. Table 5-67 presents information on the model apartment containing nonfriable vinyl floor tile. The model parameters for the removal of the nonfriable A/C sheet are presented in Table 5-68.

TABLE 5-63. ASBESTOS MATERIALS IN SUB-THRESHOLD STRUCTURE

Location of asbestos	Amount of asbestos	Type and thickness of asbestos
Furnace	6.7 m^2 (72 ft^2)	7.6-cm (3-in.) trowelled-on material
12.7-cm (5-in.) ducts	18.3 m (60 ft)	5-cm (2-in.) premolded insulation

TABLE 5-64. MODEL PARAMETERS FOR DEMOLITION AND RENOVATION OF SUB-THRESHOLD STRUCTURE

<u>Demolition</u>	
Asbestos removed	
Furnace	0.5 m^3 (18 ft^3)
Ducts	0.5 m^3 (18 ft^3)
Asbestos waste generated	3 m^3 (4 yd^3)
<u>Renovation</u>	
Asbestos removed	
Furnace	0.5 m^3 (18 ft^3)
Asbestos waste generated	2 m^3 (3 yd^3)

TABLE 5-65. NONFRIABLE VINYL FLOOR TILE IN AN APARTMENT BUILDING

Location of asbestos	Amount of asbestos	Type and thickness of asbestos
Flooring	700 m^2 (7,500 ft^2)	0.16-cm (0.0625-in.) vinyl floor tile

TABLE 5-66. MODEL PARAMETERS FOR DEMOLITION AND RENOVATION OF APARTMENT BUILDING CONTAINING VINYL FLOOR TILE

Building area	766 m^2 (8,250 ft^2)
Demolition	
Asbestos removed	
Flooring	1 m^3
Asbestos waste	3 m^3
Renovation	
Asbestos removed	
Flooring	0.4 m^3 (13 ft^3)
Asbestos waste generated	1.2 m^3 (1.4 yd^3)

TABLE 5-67. NONFRIABLE A/C SHEET IN AN INDUSTRIAL BUILDING

Location of asbestos	Amount of asbestos	Type and thickness of asbestos
Exterior siding and roofing	2,300 m^2 (24,750 ft^2)	0.6-cm (0.25-in.) A/C sheet

TABLE 5-68. MODEL PARAMETERS FOR REMOVAL OF NONFRIABLE A/C SHEET FROM INDUSTRIAL BUILDING

Building area	1,650 m^2 (17,750 ft^2)
Asbestos removed	
Siding and roofing	14 m^3 (516 ft^3)
Asbestos waste generated	42 m^3 (57.3 yd^3)

5.1.1.13.3 Built-up roofing. A three-story, five-unit apartment building was selected for the model containing built-up roofing. The model apartment building has a total floor area of 7,500 ft^2 and contains 2,500 ft^2 of built-up roofing. The demolition of the building is done floor by floor. In the renovation model, the entire 2,500 ft^2 of asbestos roofing material is being replaced. Table 5-69 presents information on the model apartment containing built-up roofing. The model parameters for the removal of the asbestos-containing built-up roofing are presented in Table 5-70.

5.1.2 Milling

Asbestos milling is the process by which asbestos fibers are separated from the raw ore, through either a dry or wet process. The four existing U.S. plants have annual production capacities ranging from about 1,000 to 65,000 tons. Solid wastes are produced in the form of mill tailings and baghouse wastes. Tailings usually are wetted before being dumped onto the disposal pile; baghouse wastes may be partly recycled to the process or may be wetted and transported to the tailings pile. Solid waste may be treated with chemical dust suppressants to prevent wind erosion.

Two model plants for asbestos mills are presented to cover the range in sizes of U.S. mills as well as the types of ore processing used. One uses a wet milling process and the other a dry process. A typical asbestos mill may process ore at a rate of 280 ton/hr and have a production capacity of 65,000 ton/yr of raw asbestos fibers. Such a plant may operate 6,000 to 8,700 h/yr and generate approximately 270 ton/hr of solid waste. Table 5-71 presents operating parameters for the model asbestos mills.

5.1.3 Manufacturing

5.1.3.1 Paper Manufacturing. The manufacturing of paper products is carried out by processes very similar to those used in other paper manufacturing operations. Asbestos fibers are mixed with water and other ingredients, and the slurry is then processed into paper. Existing plants have production capacities ranging from about 550 to 140,000 ton/yr. In some plants dry asbestos fibers are dumped from bags into the process stream, while in other plants pulpable bags are used and the unopened bags are added to the papermaking process. If bag dumping is employed, the

TABLE 5-69. NONFRIABLE BUILT-UP ROOFING IN AN APARTMENT BUILDING

Location of asbestos	Amount of asbestos	Type and thickness of asbestos
Roofing	232 m^2 (2,500 ft^2)	7.6-cm (3.0-in.) built-up roofing

TABLE 5-70. MODEL PARAMETERS FOR REMOVAL OF NONFRIABLE ASBESTOS-CONTAINING BUILT-UP ROOFING FROM APARTMENT BUILDING

Building area	766 m^2 (8,250 ft^2)
Asbestos removed	
Built-up roofing	17.7 m^3 (625 ft^3)
Asbestos waste generated	53.1 m^3 (69.4 yd^3)

TABLE 5-71. OPERATING PARAMETERS FOR ASBESTOS MILLS

Typical dry asbestos mill	
Plant capacity	65,000 ton/yr
Annual production	40,000 tons
Solid waste generated	1,700,000 ton/yr
Annual operating hours	6,240
Emission control[a]	
Baghouse	2 @ 45,000 cfm 1 @ 40,000 cfm 1 @ 400,000 cfm
Inlet loading	9.8 grains/acf
Wet asbestos mill	
Plant capacity	65,000 ton/yr
Annual production	40,000 tons
Solid waste generated	20,000 ton/yr
Annual operating hours	6,240
Emission control	
Baghouse	2 @ 20,000 cfm 2 @ 15,000 cfm 2 @ 10,000 cfm
Inlet loading	9.8 grains/acf

[a]cfm = cubic feet per minute
acf = actural cubic feet

mixing process must be controlled by local exhaust ventilation (LEV) systems and the air sent to a purifying system before being recycled or exhausted. In these cases, solid waste is generated in the emission control system and by the empty bags. Other solid wastes are generated by purification of process wastewater. If pulpable bags are used, LEV systems are not required and the only solid waste is produced through purification of process wastewater. Baghouse wastes normally are returned to the manufacturing process, and wastewater sludge normally is disposed of at a landfill. A small amount of solid waste is generated from waste products, but most of it can be recycled into the manufacturing process.

Model plants were developed for three sizes of paper manufacturing plants. A small plant may produce 3,000 to 6,000 ton/yr of product and consume about 3,750 to 7,500 ton/yr of raw asbestos fibers. Annual operating hours may range from 4,000 to 6,000, and solid waste generation may range from 4 to 7 ton/yr. Waste is hauled to a public or private off-site landfill or is disposed of on site.

A typical plant may produce 15,000 to 25,000 ton/yr of paper and consume 11,000 to 16,000 ton/yr of raw asbestos fibers. Annual operating hours may range from 4,000 to 6,000, and solid waste generation may range from 18 to 30 ton/yr. Waste is hauled to an off-site landfill for disposal.

A large plant may produce from 65,000 to 115,000 ton/yr of paper and consume 48,000 to 85,000 ton/yr of raw asbestos fibers. Annual operating hours may range from 4,000 to 6,000 and waste generation may range from 78 to 138 ton/yr. Waste is hauled to an off-site landfill for disposal. Table 5-72 presents operating parameters for the three sizes of model plants.

5.1.3.2 Friction Materials Manufacturing. The manufacture of friction materials begins when asbestos fibers are mixed with other raw materials to produce a slurry, which is then formed or molded into the friction product and dried or cured. Finished products then pass through finishing operations and are packaged. LEV systems are used on many of the operations to control worker exposure to asbestos fibers. Exhausts from the LEV systems are passed through baghouses or wet scrubbers. Solid wastes consist of product scrap, baghouse and vacuum cleaner material, wastewater solids, and empty asbestos bags. Friction material wastes normally are not recycled to the manufacturing process.

TABLE 5-72. MODEL PLANT PARAMETERS FOR ASBESTOS PAPER MANUFACTURING PLANTS

Small paper manufacturing plant	
Production capacity	6,475 ton/yr
Annual production	3,700 tons
Asbestos consumed	2,760 ton/yr
Solid waste generated	4.4 ton/yr
Annual operating hours	5,760
Emission control	
Baghouse	1 @ 25,000 cfm 1 @ 10,000 cfm
Inlet loading	0.1 grain/acf
Typical paper manufacturing plant	
Production capacity	32,400 ton/yr
Annual production	18,500 tons
Asbestos consumed	13,800 ton/yr
Solid waste generated	22 ton/yr
Annual operating hours	5,760
Emission control	
Baghouse	3 @ 25,000 cfm 1 @ 10,000 cfm
Inlet loading	0.1 grain/acf
Large paper manufacturing plant	
Production capacity	130,000 ton/yr
Annual production	74,300 tons
Asbestos consumed	55,450 ton/yr
Solid waste generated	89 ton/yr
Annual operating hours	5,760
Emission control	
Baghouse	6 @ 25,000 cfm 5 @ 10,000 cfm
Inlet loading	0.1 grain/acf

Three sizes of model plants were developed for friction material manufacturing. The small model plant has two variations: one with on-site and one with off-site solid waste disposal. Small plants have a production capacity ranging from 800 to 1,500 ton/yr and consume 520 to 1,000 ton/yr of asbestos. Plants operate 4,000 to 6,000 hr/yr and generate 88 to 165 ton/yr of solid waste.

A typical friction products manufacturing plant may produce 2,500 to 4,000 ton/yr of product and consume 1,600 to 2,600 ton/yr of asbestos. Annual operating hours may range from 4,000 to 6,000, and solid waste generation may range from 275 to 440 ton/yr. Asbestos waste is disposed of in an off-site landfill.

A large plant may produce 5,000 to 10,000 ton/yr of friction materials and consume 3,200 to 6,500 ton/yr of asbestos. Annual operating hours may range from 4,000 to 6,000, and solid waste generation may range from 550 to 1,100 ton/yr. An off-site landfill is used for disposal of asbestos-containing waste. Operating parameters for the three sizes of model plants are given in Table 5-73.

5.1.3.3 A/C Products Manufacturing. A/C products consist mainly of sheet and pipe. The manufacturing process for both products involves mixing of asbestos fibers with other ingredients to form a slurry, which is formed into sheet or pipe and then dried or cured. The products may then pass through one or more finishing operations. Solid waste is generated by scrap material, baghouse and vacuum cleaner wastes, wastewater solids, and empty bags. Because plant sizes do not vary greatly across the industry, model plants represent typical A/C pipe and sheet manufacturing plants. Each model plant has two variations: on-site and off-site solid waste disposal.

A typical A/C pipe manufacturing plant may produce 75,000 to 125,000 ton/yr and consume 15,000 to 25,000 ton/yr of raw asbestos fibers. Annual operating hours may range from 5,000 to 8,000, and annual solid waste generation may range from 1,000 to 2,000 tons.

A typical A/C sheet manufacturing plant may produce 5,000 to 10,000 ton/yr of A/C sheet and consume 1,250 to 2,500 ton/yr of raw asbestos fibers. Annual operating hours may range from 5,000 to 8,000, and annual solid waste generation may range from 250 to 500 tons. Table 5-74 presents operating parameters for the model plants.

TABLE 5-73. MODEL PLANT PARAMETERS FOR ASBESTOS FRICTION MATERIALS MANUFACTURING PLANTS

Small friction materials manufacturing plant	
Production capacity	2,450 ton/yr
Annual production	1,250 tons
Asbestos consumed	800 ton/yr
Solid waste generated	135 ton/yr
Annual operating hours	5,520
Emission control	
Baghouse	6 @ 15,000 cfm 4 @ 10,000 cfm 1 @ 7,500 cfm
Inlet loading	0.72 grain/acf
Typical friction materials manufacturing plant	
Production capacity	6,000 ton/yr
Annual production	3,100 tons
Asbestos consumed	2,000 ton/yr
Solid waste generated	340 ton/yr
Annual operating hours	5,520
Emission control	
Baghouse	9 @ 15,000 cfm 6 @ 10,000 cfm 1 @ 7,500 cfm
Inlet loading	0.72 grain/acf
Large friction materials manufacturing plant	
Production capacity	14,700 ton/yr
Annual production	7,500 tons
Asbestos consumed	4,800 ton/yr
Solid waste generated	825 ton/yr
Annual operating hours	5,520
Emission control	
Baghouse	15 @ 15,000 cfm 10 @ 10,000 cfm 1 @ 7,500 cfm
Inlet loading	0.72 grain/acf

TABLE 5-74. MODEL PLANT PARAMETERS FOR A/C PRODUCTS MANUFACTURING

Typical A/C pipe manufacturing plant	
Production capacity	150,000 ton/yr
Annual production	100,000 tons
Asbestos consumed	20,000 ton/yr
Solid waste generated	1,500 ton/yr
Annual operating hours	7,344
Emission control	
Baghouse	2 @ 20,000 cfm 2 @ 25,000 cfm 2 @ 40,000 cfm
Inlet loading	1.17 grains/acf
Typical A/C sheet manufacturing plant	
Production capacity	10,000 ton/yr
Annual production	7,000 tons
Asbestos consumed	1,750 ton/yr
Solid waste generated	350 ton/yr
Annual operating hours	7,344
Emission control	
Baghouse	7 @ 15,000 cfm 4 @ 10,000 cfm
Inlet loading	1.17 grains/acf

5.1.3.4 V/A Floor Tile Manufacturing. In the manufacturing of V/A floor tile, raw asbestos fibers are mixed with other ingredients to form a slurry, which is formed into sheets, calendared to desired thickness, cooled, and cut into squares. Dry asbestos fibers may be emptied into the process or fibers may be introduced in unopened bags. Most product scrap is recycled into the manufacturing process, so solid waste generation is extremely small. Solid waste consists mostly of baghouse and vacuum cleaner waste and of empty bags when bag emptying is practiced. Model plants were developed for small and typical operations. Waste disposal for both models is in an off-site landfill.

A small V/A floor tile manufacturing plant may produce 5,000 to 10,000 ton/yr of tile and consume 600 to 1,200 ton/yr of raw asbestos fibers. Annual operating hours may range from 4,000 to 7,000, and solid waste generation may range from 4 to 7 ton/yr.

A typical V/A floor tile plant may produce 20,000 to 40,000 ton/yr of product and consume 2,400 to 4,800 ton/yr of raw asbestos fibers. Annual operating hours may range from 4,000 to 7,000, and solid waste generation may range from 15 to 30 ton/yr. Table 5-75 presents operating parameters for two model plants.

5.1.3.5 Asbestos-Reinforced Plastics (Phenolic Molding Compounds). Asbestos fibers are added to phenolic molding compounds to provide strength, durability, and dimensional stability. Dry asbestos fibers are added to the other ingredients in dry form, and the mixture is then processed into the plastic products by molding or extrusion. Products may pass through several finishing operations after forming and curing are completed. Dust-generating operations are controlled by LEV systems, which typically are vented to baghouses. Solid waste consists of baghouse waste, scrap product, and empty bags. Baghouse waste typically is recycled into the manufacturing process. Other solid waste normally is disposed of in an off-site landfill. Model plants were developed for small and typical manufacturers of phenolic molding compounds. A small plant may produce 300 to 600 ton/yr of reinforced plastic and consume 60 to 120 ton/yr of raw asbestos fibers. Annual operating hours may range from 3,600 to 7,200, and annual waste generation may range from 18 to 36 tons.

TABLE 5-75. MODEL PLANT PARAMETERS FOR V/A FLOOR TILE MANUFACTURING

Small V/A floor tile manufacturing plant	
Production capacity	16,000 ton/yr
Annual production	9,000 tons
Asbestos consumed	1,000 ton/yr
Solid waste generated	6 ton/yr
Annual operating hours	6,000
Emission control	
Baghouse	1 @ 50,000 cfm
Inlet loading	0.19 grain/acf
Typical V/A floor tile manufacturing plant	
Production capacity	50,000 ton/yr
Annual production	30,000 tons
Asbestos consumed	3,600 ton/yr
Solid waste generated	22 ton/yr
Annual operating hours	6,000
Emission control	
Baghouse	3 @ 50,000 cfm
Inlet loading	0.19 grain/acf

A typical plant may produce 1,500 to 2,500 ton/yr of reinforced plastic and consume 300 to 500 ton/yr of raw asbestos fibers. Annual operating hours may range from 4,000 to 8,000, and solid waste generation may range from 90 to 150 ton/yr. Table 5-76 shows operating parameters for the two model plants.

5.1.3.6 Coatings and Sealants Manufacturing. Asbestos fibers are mixed with other ingredients, mostly asphalt materials, to form the end product for this industry segment. Bag opening and mixing processes are exhausted to baghouses. Baghouse waste is recycled to the manufacturing process, so the only solid waste to be disposed of is empty bags, which normally are landfilled off-site. Because existing plants do not vary substantially in size, a single model plant is used to represent a typical coatings and sealant manufacturer.

Annually, a typical plant may produce 3 to 6 million gallons of product and consume 1,200 to 2,400 tons of asbestos. Annual operating hours average about 6,000. Table 5-77 presents operating parameters for the model plant.

5.1.3.7 Gaskets and Packings Manufacturing. Asbestos gaskets are produced by the combination of asbestos fibers with other ingredients to form a mixture that is calendared into a sheet and cut to desired shapes. Solid waste from the process consists of scrap product, baghouse wastes, and empty bags. Packings are made by impregnating dry asbestos yarn with lubricants and braiding the yarn into the packing, which is then calendared to desired sizes and shapes. Product scrap is the major source of solid waste, which is disposed of in off-site landfills. A model plant was developed to represent a typical manufacturer of asbestos packings and gaskets. A typical plant may produce 400 to 800 ton/yr of product and consume 340 to 680 ton/yr of asbestos. Annual operating hours may range from 4,000 to 8,000, and annual waste generated may range from 18 to 36 tons. Operating parameters for the model plant are given in Table 5-78.

5.1.3.8 Asbestos Textiles Manufacturing. Asbestos textiles generally are manufactured by the conventional dry process used in other textile operations. A small fraction is produced through a wet process whereby asbestos fibers are mixed into a slurry, which is then extruded to form

TABLE 5-76. MODEL PLANT PARAMETERS FOR PHENOLIC MOLDING COMPOUND MANUFACTURING

Small phenolic molding compound manufacturing plant	
Production capacity	800 ton/yr
Annual production	450 tons
Asbestos consumed	90 ton/yr
Solid waste generated	25 ton/yr
Annual operating hours	6,000
Emission control	
Baghouse	1 @ 25,000 cfm
Inlet loading	0.05 grain/acf
Typical phenolic molding compound manufacturing plant	
Production capacity	3,000 ton/yr
Annual production	1,800 tons
Asbestos consumed	360 ton/yr
Solid waste generated	100 ton/yr
Annual operating hours	6,000
Emission control	
Baghouse	4 @ 20,000 cfm
Inlet loading	0.05 grain/acf

TABLE 5-77. MODEL PLANT PARAMETERS FOR COATINGS AND SEALANTS MANUFACTURING

	Typical coatings and sealants manufacturing plant
Production capacity	10,000,000 gal/yr
Annual production	5,400,000 gallons
Asbestos consumed	2,200 ton/yr
Solid waste generated	30 ton/yr
Annual operating hours	6,000
Emission control	
Baghouse	5 @ 2,000 cfm
Inlet loading	0.1 grain/acf

TABLE 5-78. MODEL PLANT PARAMETERS FOR PACKINGS AND GASKETS MANUFACTURING

	Typical packings and gaskets manufacturing plant
Production capacity	1,000 ton/yr
Annual production	600 tons
Asbestos consumed	510 ton/yr
Solid waste generated	27 ton/yr
Annual operating hours	6,000
Emission control	
Baghouse	3 @ 5,000 cfm 1 @ 100,000 cfm
Inlet loading	0.002 grain/acf

yarn. Solid waste is generated by product scrap, baghouse waste, and empty bags. Some of the baghouse wastes are recycled into the manufacturing process. A model plant for asbestos textiles was developed to represent a typical existing plant. A typical plant may produce 200 to 500 ton/yr of asbestos textiles and consume 170 to 425 ton/yr of raw asbestos fibers. Annual operating hours may range from 3,000 to 6,000, and annual solid waste generation may range from 10 to 25 tons. Waste may be disposed of either on site or off site. Model plant operating parameters are given in Table 5-79.

5.1.3.9 Chlorine Manufacturing. One of the major chlorine manufacturing methods employs an asbestos diaphragm in the process. LEV systems are used to control worker exposure in bag opening and mixing operations. The LEV system exhaust is filtered before being recycled or exhausted to the atmosphere. The asbestos diaphragms must be replaced periodically and constitute the major source of solid waste. Other solid waste consists of LEV system filters, vacuum cleaner waste, and empty bags. An off-site landfill is used for disposal of asbestos waste. All of the asbestos consumed in the process must be disposed of in the form of solid waste. A model plant was developed to represent a typical chlorine manufacturing plant.

Annually, a typical plant may produce 160,000 to 320,000 tons of chlorine and consume 20 to 40 tons of asbestos. Annual operating hours may range from 6,000 to 8,000, and annual solid waste generation may range from 400 to 800 tons. Operating parameters for a typical chlorine manufacturing plant are given in Table 5-80.

5.1.3.10 Asphalt Concrete Manufacturing. Asbestos has been added to asphalt to give it greater strength and longer life and is used as a thin topping layer on some airport runways, roadways, bridges, and street curbing. Bags of asbestos are opened manually and dumped into a conveyor system or are introduced unopened into the mixer. The asbestos is mixed first with dried aggregate after which hot liquid asphalt is added to the asbestos-containing aggregate and thoroughly mixed. Empty bags, if not incorporated into the mixture, become waste. A model plant was developed to represent a typical manufacturer of asphalt concrete. A typical plant may produce 187,500 ton/yr of product and operate about 750 hours annually.

TABLE 5-79. MODEL PLANT PARAMETERS FOR ASBESTOS TEXTILE PLANT

	Typical asbestos textile plant
Production capacity	700 ton/yr
Annual production	350 tons
Asbestos consumed	300 ton/yr
Solid waste generated	18 ton/yr
Annual operating hours	4,000
Emission control	
Baghouse	5 @ 15,000 cfm 1 @ 20,000 cfm
Inlet loading	0.05 grain/acf

TABLE 5-80. MODEL PLANT PARAMETERS FOR CHLORINE MANUFACTURING PLANT

	Typical chlorine manufacturing plant
Production capacity	450,000 ton/yr
Annual production	240,000 tons
Asbestos consumed	30 ton/yr
Solid waste generated	600 ton/yr
Annual operating hours	7,200
Emission control	
Baghouse	1 @ 1,200 cfm
Inlet loading	0.1 grain/acf

Annual asbestos waste generated is negligible. Operating parameters for the model plant are given in Table 5-81.

5.1.4 Fabricating Processes

Model plants were developed for three types of secondary fabricators of asbestos products: friction products, A/C building products, and A/C or asbestos-silicate boards.

5.1.4.1 Friction Products. Secondary fabrication of friction products mostly involves rebuilding of automotive brakes and clutches, with brakes the major component. Automotive brake rebuilding consists of applying new brake linings on used brake shoes. In the process, remnants of the old brake linings are removed from the shoes, new linings are installed, and the linings are ground to the proper shape. Solid waste is generated by removal of the old linings and by the grinding operations.

A typically sized brake-rebuilding operation may produce 300,000 to 500,000 brake shoes per year. No raw asbestos fibers are consumed in the process. The plant may operate 5,000 to 7,200 hr/yr and generate 5 to 8 ton/yr of solid waste, which is disposed of off site. Operating parameters for a model brake-shoe-rebuilding plant are given in Table 5-82.

5.1.4.2 A/C Building Products. In some cases, construction contractors specify that A/C building products be prefabricated to eliminate or greatly reduce field fabrication of the products. Prefabrication normally is at central shops operated by distributors of A/C building products. Solid waste is generated by sawing and drilling operations and by product scrap.

A typical prefabricator of A/C building products might prefabricate 15 to 30 ton/yr of A/C building products. Annual operating hours may range from 2,000 to 4,000, and solid waste generation may range from 2.5 to 5 ton/yr. Asbestos waste is hauled to an off-site landfill for disposal. Operating parameters for a typical prefabricator of A/C building products are given in Table 5-83.

5.1.4.3 A/C and Asbestos Silicate Boards. Both A/C and asbestos silicate boards are used by a number of secondary fabricators. These boards are used for exhaust hoods in corrosive atmospheres, laboratory furniture, molten metal flow control systems, ovens, and electrical panels.

TABLE 5-81. MODEL PLANT PARAMETERS FOR ASPHALT CONCRETE PLANT

	Typical asphalt concrete plant
Production capacity	375,000 ton/yr
Annual production	187,500 tons
Asbestos consumed	
Solid waste generated	Negligible
Annual operating hours	750
Emission control	
Baghouse	1 @ 42,000 cfm
Inlet loading	5.5 grains/acf

TABLE 5-82. MODEL PLANT PARAMETERS FOR BRAKE-SHOE-REBUILDING PLANT

	Typical brake-shoe-rebuilding plant
Production capacity	800,000 shoes/yr
Annual production	440,000 shoes
Solid waste generated	7.35 ton/yr
Annual operating hours	6,000
Emission control	
Baghouse	1 @ 7,000 cfm
Inlet loading	0.04 grain/acf

TABLE 5-83. MODEL PLANT PARAMETERS FOR PREFABRICATOR OF A/C BUILDING PRODUCTS

	Typical prefabrication of A/C building products
Production capacity	50 ton/yr
Annual production	20 tons
Solid waste generated	3.4 ton/yr
Annual operating hours	2,400
Emission control	
Baghouse	1 @ 19,000 cfm
Inlet loading	0.02 grain/acf

Larger users of asbestos boards have their own fabricating shops, while other users have the boards fabricated to specifications by central specialty shops.

A single model plant was developed to represent a typical fabricator of asbestos boards. Solid waste is generated by these fabricators from sawing, drilling, and machining operations. The solid waste may be disposed of in either on-site or off-site landfills. A typical asbestos fabricator may use 100 to 200 ton/yr of board. Annual operating hours may range from 2,000 to 3,000, and solid waste generation may range from 25 to 50 ton/yr. Operating parameters for a typical fabricator of asbestos boards are given in Table 5-84.

5.1.5 Waste Disposal Sites

Asbestos-containing solid waste is generated by demolition and renovation activities, by manufacturing operations, and by fabrication of asbestos-containing materials. Solid waste from demolition and renovation consists mostly of friable asbestos materials removed from boilers, vessels, pipes, ceilings, walls, and structural members. Solid waste from manufacturing operations consists of scrap product, baghouse and vacuum cleaner wastes, process wastewater solids, and bags emptied of asbestos. Fabrication of asbestos-containing products generates baghouse and vacuum cleaner waste and scrap product.

Solid waste from all of the above sources normally is disposed of at landfills. Demolition and renovation wastes normally are hauled to publicly or privately owned landfills near the demolition or renovation activity. Hauling may be by the contractor or by a licensed waste hauler. Manufacturing and fabricating waste may be disposed of at on-site landfills operated by the company or at off-site landfills. If off-site landfills are used, hauling may be contracted to a hauler or may be done in company trucks by company employees.

Two model waste disposal sites were developed. One is a small privately owned landfill and the other is a large publicly owned landfill. Both accept wastes from many sources.

The small private landfill handles the waste disposal needs of a small town located nearby. The facility handles approximately 50 tons of waste per day and only about 5 tons (approximately 15 yd^3) of asbestos waste per

TABLE 5-84. MODEL PLANT PARAMETERS FOR ASBESTOS BOARD FABRICATION

	Typical asbestos board fabrication
Production capacity	300 ton/yr
Annual production	135 tons
Solid waste generated	35 ton/yr
Annual operating hours	2,400
Emission control	
Baghouse	1 @ 11,000 cfm
Inlet loading	0.1 grains/acf

week. The landfill requires that all asbestos waste be sealed in plastic bags and contained in fiber drums. Asbestos waste is unloaded and placed with other waste and is covered at the end of each work day.

The public landfill is a large sanitary landfill that accepts asbestos-containing waste in a separate area of the site. All asbestos waste must be in sealed containers to be accepted by the landfill. Containers are unloaded by hand and are covered with earth at the end of each day. The landfill disposes of approximately 1,000 tons of waste daily but only 50 tons (about 152 yd^3) of asbestos waste weekly. The asbestos waste comes mostly from demolition and renovation work.

5.2 REGULATORY ALTERNATIVES

This section discusses regulatory alternatives to be considered for the asbestos source category. A wide range of industrial and commercial sources of asbestos emissions are subject to the existing standard. These include: asbestos milling, manufacturing, and fabricating operations; demolition and renovation operations; the spray application of asbestos-containing materials; the use of asbestos insulation materials; and the use of asbestos wastes on roadways. Provisions also are included for asbestos waste disposal.

5.2.1 Milling, Manufacturing, and Fabricating

5.2.1.1 HEPA Filters. A regulatory alternative intended virtually to eliminate emissions would be the requirement that high-efficiency particulate air (HEPA) filters be added to all air-cleaning devices as final filters. In most instances, HEPA filters, rated at 99.97 percent efficiency on 0.3-μm particles, would require preconditioning systems (e.g., prefilters or demisters) to prevent rapid overloading of the filters. Pressure drops should not be allowed to exceed values recommended to ensure proper operation. Pressure drop could be monitored manually or continuously by using a pressure transducer and recording device. Manufacturers' suggestions on when to change filters should be followed.

A variation of this alternative would be to require HEPA filters as the final element of all air-cleaning devices for any new or modified facilities, but to require continuous optical monitoring equipment for existing facilities. Increases in opacity readings of 5 percent or more would require immediate internal inspection of the baghouse. The monitor would be maintained according to manufacturers' recommendations.

5.2.1.2 Comply With No Visible Emissions (VE) and Equipment Specifications. Under this alternative, the existing provisions would be retained except that air pollution control devices would be required to operate without visible emissions in addition to being required to meet the design and operating specifications for control devices contained in the NESHAP. Inlet grain loadings for some control devices are so low that visible emissions would be unlikely under most circumstances. Requiring compliance with the design and operating specifications would help to ensure that emissions are effectively controlled. The 4-inch water gauge requirement would be deleted for all existing and new baghouses because many baghouses remove particulate matter at high efficiencies at higher pressure drops. For plants that operate control devices not conforming exactly to all of the NESHAP's design and operating specifications, the NESHAP contains provisions for approval by the Administrator of equivalent control devices. This alternative would also prohibit visible emissions from fugitive sources, such as doors and windows of buildings.

5.2.1.3 Shutdown and Repair of Malfunctions. Under this alternative, when a control device malfunction results in increased asbestos emissions, the malfunctioning control device and associated process would be required to be shut down immediately. Corrective action to repair malfunctions would be required prior to returning the control device to service. This revision would codify what is considered good operating practice and would make explicit what is implied by Section 61.152(a)(2), which requires the proper installation, use, and operation of control devices.

5.2.1.4 Eliminate No Visible Emissions As an Option and Require Work Practices in Waste Handling. Under the current NESHAP, two compliance options are available: (1) discharge no visible emissions to the outside air during the collection, processing (including incineration), packaging, transporting, or deposition of any asbestos-containing waste material generated by the source; or (2) follow one of the work practices contained in the rule. The work practices include the following:

- Mix asbestos waste from control devices with water to form a slurry; adequately wet other asbestos-containing waste material
- Discharge no VE to the outside air from collection, mixing, and wetting operations
- After wetting, seal all asbestos-containing waste material in leak-tight containers while wet

Instead of wetting, waste may be processed into nonfriable forms.

This alternative would require the use of work practices whenever handling asbestos waste and would eliminate the compliance option of no visible emissions.

5.2.2 Demolition and Renovation

5.2.2.1 Reduce Threshold for Work Practices. Four alternatives for reducing the threshold for work practices are considered. The first would eliminate the threshold amounts of asbestos from the rule and require all demolitions and renovations involving any amount of asbestos to be performed in compliance with NESHAP work practice requirements. Residential buildings with four or fewer dwelling units would be excluded. Owners/operators planning renovations involving less than the current threshold amounts of asbestos would not be required to notify EPA of their intentions.

The second alternative also would eliminate the threshold amounts of asbestos from the rule and require all demolitions and renovations involving any amount of asbestos to be performed in compliance with NESHAP work practice requirements, and also would exclude residential buildings with four or fewer dwelling units. Owners/operators planning renovations involving any asbestos would be required to notify EPA of their intentions.

The third alternative would adopt the quantities of asbestos set forth in the definition of the Small-Scale, Short Duration Exemption proposed by OSHA (65 FR 29717, July 20, 1990) as the thresholds; i.e., 21 lin ft and 9 ft^2. Residential buildings with four or fewer dwelling units would be excluded. Owners/operators planning renovation involving less than the current threshold amounts of asbestos would not be required to notify EPA of their intentions.

The fourth alternative also would adopt the OSHA Small-Scale, Short Duration Exemption quantities of asbestos (21 lin ft and 9 ft^2) as thresholds and also would exclude residential buildings with four or fewer dwelling units. Owners/operators planning renovations involving at least 21 lin ft or 9 ft^2 of asbestos would be required to notify EPA of their intentions.

5.2.2.2 Procedures for Identifying Non-notifiers. Local building codes in many areas of the United States require property owners to obtain a permit before they demolish or renovate a building. It is estimated that about 80 percent of communities with populations of 2,500 or more have permitting systems in place.[1] Compliance with permitting requirements varies from community to community. The permitting systems are usually administered by the local code enforcement agency, e.g., a building inspection department. In general, permits are issued only after the owner (or contractor) completes an application for a permit that describes the proposed construction activity. Many communities charge a fee for these permits. Copies of permit applications and permits issued are kept on file by code enforcement agencies.

These files constitute an independent source of information on demolitions and renovations being performed in the community. As such, they can be used to supplement the information obtained through the NESHAP notification process. They could be used either to identify current demolition/renovation activities that may involve asbestos for which a notification has not been received or to identify past instances in which no notification was received for a demolition or renovation. EPA Regions I and III have conducted audits of the records of some building inspection departments to evaluate them as a source of information on demolitions and renovations.[2,3] Region I concluded that building inspection records are a useful source of information on non-notifiers, whereas Region III questioned their utility since information on asbestos was not forthcoming. Nevertheless, since a notification is required for all demolitions, review of demolition permits should be a useful procedure to identify non-notifiers. This is considered to be most useful for local air pollution control agencies because they are located physically near the code enforcement agencies and can conveniently review permits.[4]

The extent that local agencies make use of this source of information varies widely. In some communities, the code enforcement agencies are cooperating very closely with the air pollution control authorities to ensure that the notification requirements are met and the air pollution control authorities are made aware of the proposed activity. For example, in Washington, DC, a razing permit will not be issued to a contractor unless it is approved by the Department of Consumer and Regulatory Affairs,[5] and, in Wilmington, Delaware, applicants for demolition permits must first contact the Asbestos NESHAP Coordinator in the Air Section who then visits the demolition site. A demolition permit is not granted without the approval of the Air Section.[6] In Asheville, North Carolina, a city ordinance requires the approval of the Western North Carolina Regional Air Pollution Control Board before demolition permits are issued. There the pollution control agency accesses demolition permit applications on a computer terminal connected to the code enforcement agency's computer.[7] Intermediate in the amount of attention it gives to asbestos is Charleston, West Virginia, where the Building Commissioner's Office may verbally inform the contractor that asbestos-containing material should be removed before the demolition is performed.[8] Other local code enforcement agencies neither require information on asbestos as part of the application nor do they inform the applicant of his responsibility to comply with the NESHAP.

The regulatory options under consideration include requiring code enforcement agencies to:

- Inform all applicants for demolition permits that they must notify EPA
- Inform applicants for renovation permits that they must notify EPA if the job involves 160 ft^2 or 260 lin ft of asbestos
- Collect information on asbestos as part of the permit application

The Office of General Counsel indicates that the Clean Air Act does not confer the authority to require local governments to perform any of these options.[9] However, if the Clean Air Act reauthorization provides the requisite authority, these options might be considered.

Alternatively, EPA could encourage States to legislate cooperation between local code enforcement agencies and air pollution control agencies, since State legislatures clearly have the power to require such cooperation.[10] Thus, code enforcement agencies could be required to inform air pollution control organizations of demolition/renovation permits sought and/or issued, and even to collect information on asbestos as part of the permit application.

While the legal authority to implement these options as a rule is non-existent at present and uncertain in the future, there is nothing to prevent EPA from working with code enforcement agencies on a nonregulatory basis. As noted above, this approach has already been used by EPA Regions I and III to identify non-notifiers. Instead of requiring code enforcement agencies to perform these options, EPA could inform these agencies of the asbestos NESHAP and the importance of the asbestos problem and solicit their help on a cooperative basis. All of the options under consideration are suitable for implementation through education and cooperation. Moreover, since local code enforcement agencies have the option of requiring the approval of the cognizant air pollution control agency before issuing a permit, EPA may wish to encourage such local cooperation.

5.2.2.3 Require Use of Wetting Agents. The current regulation does not require the use of wetting agents. This alternative would require use of amended water or other liquids such as removal encapsulants during demolitions and renovations whenever wetting is required. The amended water or other liquids such as removal encapsulants would be required to have a surface tension no greater than 35 dynes/cm as determined by the capillary rise method or an equivalent method. The use of wetting agents improves the effectiveness of wetting and reduces the release of airborne asbestos.

5.2.2.4 Require Use of Negative-Pressure HEPA Filter Systems. This alternative would apply to all asbestos removals and would require work areas to be enclosed and maintained under negative pressure with all exhaust air passing through a HEPA filter. Each filter must meet construction and operation requirements that will be designated by EPA. In part, these requirements include 1,100 ft^3/min nominal minimum rating, maximum pressure drop of 1 in. H_2O clean resistance, and efficiency not less than 99.97 percent when challenged with 0.3-μm dioctyl phthalate (DOP) particles. Each filter should be marked with the name of the manufacturer, serial number, air flow rating, efficiency and resistance, and direction of test air flow. No visible emissions would be permitted from the collection system. Enclosure of the work area would include either sealing off only windows or other openings and putting single or double layers of plastic over walls, floors, and openings, or using glove bag techniques. All of these methods have been used by contractors on removal jobs, especially in renovation operations involving occupied structures.

5.2.2.5. Require Training of Owners, Inspectors, and Workers. The EPA considers training of key abatement personnel an important aspect of ensuring compliance with the NESHAP. That is the purpose in the current NESHAP of requiring that an on-site representative of the demolition/ renovation owner or operator, such as a foreman or management-level person, be trained in the provisions of the NESHAP. The options under consideration would extend the training requirement to include asbestos inspectors, demolition/renovation workers, and building owners. Specifically, the five options being considered are:

- Option 1. No change; retain the current NESHAP.
- Option 2. Require training and certification of asbestos inspectors.
- Option 3. Require training and certification of asbestos inspectors and building owners/operators.
- Option 4. Require training and certification of asbestos inspectors and asbestos workers.
- Option 5. Require training and certification of asbestos inspectors, building owners/operators, and asbestos workers.

In all cases, annual refresher training would be required. By educating building owners, asbestos inspectors, and/or workers, compliance with the NESHAP would improve and asbestos emissions would be reduced.

In Option 1, no additional training requirements are proposed. The current NESHAP requires that an on-site supervisor be trained in the provisions of the NESHAP. In Options 2 through 5, additional training and certification would be required for one, all, or some combination of three categories of persons having some responsibility for asbestos abatement activities.

Training for the asbestos abatement workers would be designed to familiarize the worker with the requirements of asbestos NESHAP rules, with emphasis given to work practices required during asbestos removal and the handling of waste. Potential topics include: construction and maintenance of barriers and decontamination enclosure systems; positioning of warning signs; electrical and ventilation system lockout; proper working techniques for minimizing fiber release; use of wet methods; use of negative pressure ventilation equipment; use of HEPA vacuums; proper cleanup and disposal procedures; work practices for removal, encapsulation, enclosure, and repair; emergency procedures for sudden releases; potential exposure situations; transport and disposal procedures; and prohibited work practices. These topics are currently taught in Asbestos Hazard Emergency Response Act (AHERA) training courses for asbestos abatement workers. Courses in languages other than English will be necessary in many regions of the country.

Training for building owners or operators would be designed to make them aware of their responsibilities under the NESHAP, to give them a basic understanding of how asbestos abatement activities are to be performed, and to identify for them additional sources of information.

Training for asbestos inspectors would be designed to ensure that inspectors understand the NESHAP requirements regarding inspections for asbestos and to identify the typical locations, forms, and condition of asbestos as well as the required techniques for sampling, sample preparation, and recordkeeping.

5.2.2.6 Specify Protocol for Bulk Sample Collection. The current NESHAP specifies the procedures to be used in the analysis of bulk samples but does not contain procedures for the proper sampling of suspect material. This alternative would add specific requirements for bulk sampling and would require the same sampling protocol as that required by the AHERA regulations. Where the material is not assumed to be asbestos, samples would be required as follows:

For surfacing material

- At least three bulk samples from each homogeneous area up to 1,000 ft^2
- At least five bulk samples for homogeneous areas between 1,000 and 5,000 ft^2
- At least seven samples from homogeneous areas greater than 5,000 ft^2.

For thermal system insulation

- At least three samples from each homogeneous area
- At least one sample from each homogeneous area of patched insulation if the patched section is less than 6 linear or square feet.

5.2.2.7 Controls During Waste Handling. The current rule requires either meeting a no visible emissions requirement or using specified work practice controls during waste collection, handling, processing, and transport. The options to this requirement being considered are the following:

- Option 1. Require work practices to be used whenever handling asbestos waste; eliminate no VE as a compliance option.

- Option 2. Require compliance with both the work practices and the no VE requirement.

Work practices include wetting all asbestos waste and sealing in leak-tight wrapping, or processing waste into nonfriable forms.

5.2.2.8 Procedures for Handling and Disposal of Bulk Waste. Under the existing NESHAP, all asbestos-containing bulk waste must be adequately wetted and kept wet during handling and loading. At the disposal site such waste, like other asbestos waste, must be covered at the end of the day with 6 in. of cover or comply with the no-visible-emissions limit.

Under this alternative, additional requirements would be imposed on the handling and disposal of all bulk wastes from demolitions and renovations of asbestos-containing buildings. This alternative would require plastic lining and covering of vehicles prior to transport to disposal sites and cleaning the vehicles after transport (rinse, wipe, and vacuum with a HEPA-filter-equipped system). For exposed debris piles that remain in place more than 1 day or that are exposed to wind gusts, a temporary cover, such as a tarpaulin, must be provided. The cover would be discarded as asbestos waste if it could not be suitably cleaned after use.

5.2.2.9 Repair and Maintenance of Asbestos on Facility Components. Under this alternative, building owners would be required to maintain all asbestos-containing material in their buildings in good condition to prevent the release of asbestos fibers into the air. Activities required by this alternative would include an initial inspection to identify damaged friable materials that may contain asbestos. If no information is available that can be used to determine the presence or absence of asbestos in the identified materials, bulk sampling of damaged material would be required to determine if asbestos is present in concentrations above the action level of 1 percent. The number of samples required and the analytical methods to be used would be specified as a part of the provision.

One of the objectives of the inspection would be to identify any asbestos-containing materials that are damaged and that may release asbestos fibers into the air. If damaged asbestos-containing materials are identified, a management program would have to be undertaken. Management could consist of encapsulation, enclosure, or removal of the damaged asbestos-containing materials. Annual reinspections would be required to certify that the condition of materials that were not enclosed or removed has not changed since the last inspection. If damaged asbestos-containing materials are identified during the reinspections, additional management actions would be required.

5.2.2.10 Procedures for Nonfriable Material. The current NESHAP does not require removal of nonfriable asbestos-containing resilient floor covering, asphalt roofing products, packings, or gaskets prior to demolition of a building. Under the current NESHAP, nonfriable materials that do not become crumbled, pulverized or reduced to powder do not have to be disposed of in a NESHAP landfill. The current NESHAP regulates the sanding, grinding, abrading, or wetting of all nonfriable asbestos materials. Under this alternative, all nonfriable materials would be required to be removed prior to demolition and disposed of as asbestos waste. Any nonfriable material removed as part of demolition or renovation would be required to be disposed of in a landfill operated according to the NESHAP.

5.2.2.11 Specifications for Determining Adequacy of Removals. This alternative would specify requirements defining the suitability and completeness of asbestos removal and cleanup as part of demolition or renovation. Currently the NESHAP contains no specific requirements that specify the extent to which asbestos must be removed from a facility (i.e., how clean the facility must be) to constitute an acceptable removal operation. Two options have been identified for determining the adequacy of removal.

Under the first option, for a demolition or renovation, postabatement double cleaning of all surfaces followed by a visual inspection would be required. A cleaning would include the use of HEPA vacuums followed by wet methods with amended water until the surfaces are free of all visible residue. The second cleaning would be performed 24 hours after the first cleaning to allow time for suspended asbestos to settle.

The second option would add a requirement for clearance air monitoring after the postabatement double cleaning to demonstrate adequate removal for a demolition or renovation. Clearance air monitoring such as is required for an educational building by rules promulgated under the AHERA would involve the collection of five samples outside of each worksite and a minimum of five aggressive samples inside each worksite. Analysis would be by transmission electron microscopy (TEM). The asbestos removal action would be considered complete when the results of <u>each</u> of the samples collected in the worksite shows a concentration of less than or equal to some clearance level to be specified, such as 0.01 or 0.05 f/cm^3 of air. If the average concentration of asbestos within the worksite exceeds the clearance level, then the asbestos removal action would be considered complete when the average concentration of the five air samples collected within the worksite is not significantly different from the average of five air samples collected at the same time outside the worksite according to the statistical z-test comparison specified under the AHERA.[11]

5.2.2.12 <u>Require Viewing Ports in Enclosures</u>. As a part of an asbestos removal or renovation project, the work area is enclosed, usually in plastic. The plastic used to construct these enclosures may be "clear" or black. Even when clear plastic is used, the work area is not clearly visible from points outside the plastic enclosure and workers and work practices cannot be observed in detail. Enforcement personnel sometimes need to observe or inspect a work area to determine if proper prcedures are used by the workers. In order to make these observations, enforcement personnel or others who have a need to view the activity must personally enter the work area, an action that requires proper equipment and clothing to be worn. To reduce the effort required to enter a work area and reduce the potential for exposure to airborne asbestos fibers, the Agency considered requiring asbestos removal contractors to incorporate viewing ports in the plastic enclosures used around demolition or renovation operations. If viewing ports were incorporated into the walls that enclose the work area, inspectors could observe at least a portion of the work area. Even though all areas of the work may not be visible, observations made through a viewing port may provide sufficient information to determine if there is a need to enter the work area for further observation.

The incorporation of viewing ports can be achieved by cutting a hole in the plastic enclosure and covering the hole with glass or plexiglas taped to the plastic around the perimeter. The alternative considered would require contractors to provide work area visibility by incorporating viewing ports into the plastic.

5.2.2.13 Control Runoff from Wetting and Showers. Currently, there are no provisions in the NESHAP that directly address asbestos in waste-water from asbestos abatement operations. Under this alternative, excess water from wetting asbestos material and shower wastewater would have to be contained and disposed of as asbestos waste or filtered to remove asbestos from the water and the contaminated filters disposed of as asbestos waste.

Runoff from wetting would be collected by wet vacuum and either be disposed of as asbestos waste or filtered to remove the asbestos particles before discharge to the surface of the ground or to a sewer. Asbestos-contaminated filters would also be disposed of as asbestos waste. Since wet vacuums are commonly used, the primary effect of the alternative would be the requirement to dispose of the water as waste or to filter it.

For showers, the alternative would require asbestos-contaminated shower water to be disposed of as asbestos waste or be filtered to remove the asbestos particles before discharge to the surface of the ground or to a sewer. Contaminated filters would also be disposed of as asbestos waste. Since most shower units are equipped with filters, control of the disposal of contaminated filters is expected to be the primary effect of this alternative.

5.2.2.14. Requirements for Waste Storage and Transfer. Under this alternative, provisions would be added for the temporary storage of waste. These regulations would help avoid inadvertent public exposure, ensure that stored waste does not become an emission source, aid enforcement in tracking waste, and ensure its proper final disposal. Specific requirements would include limits on the time that waste can be stored, provisions to keep waste in locked storage areas to prevent public access, display of warning signs, weekly inspections of stored waste, prohibition of visible emissions, and records of waste storage. Under the current NESHAP, asbestos waste stored on site would be required to be kept in leak-tight containers. This alternative would require additional measures to ensure that stored waste does not become a source of emissions. Because the waste generator is responsible for ensuring that asbestos waste is taken to an appropriate disposal site under the current NESHAP, off-site temporary storage of waste is also covered. This alternative would make the off-site storage facility responsible in addition to the generator. Several States (about 20) currently regulate asbestos waste storage.

5.2.3 Waste Disposal

5.2.3.1. Regulate All Inactive Waste Disposal Sites. Under the current NESHAP, only inactive asbestos waste disposal sites operated by asbestos milling, manufacturing, and fabricating sources are covered. This alternative would extend the provisions for inactive sites to all disposal sites that accept asbestos waste, primarily to the 6,024 municipal and private solid waste landfills estimated to exist in 1988.[12] Under this alternative, all inactive waste disposal landfills that accepted asbestos waste and became inactive would be required to comply with the following:

- Place a final cover of at least 90 cm (36 in.) on the inactive site; or place a final cover on top of the asbestos-containing material that is 12 in. more than the frost penetration depth, and in no case less than 24 in.; and grow and maintain a cover of vegetation on the area adequate to prevent exposure of the asbestos-containing waste material (see Section 5.2.3.5). In desert areas, a minimum of 8 additional cm (3 in.) of crushed rock would be allowed if a vegetative cover could not be maintained.

- Grade the surface of the inactive asbestos waste disposal site so that rainwater does not pond on the surface and the cover material is not eroded.

- Record on the deed to the property a notation that the site has been used for the disposal of asbestos waste and that the survey plot and record of the location and quantity of asbestos-containing waste disposed of within the site is on file with the Administrator.

5.2.3.2 Eliminate No VE as an Option and Require Work Practices at Disposal Sites. Under the current regulation, landfills that accept asbestos waste may operate without visible emissions, cover the waste daily with 6 in. of nonasbestos cover, or apply a resinous or petroleum-based dust supressant. This alternative would require daily application of a 6-in. nonasbestos cover at all landfills or the application of a resinous or petroleum-based dust supressant. This alternative would also require mill tailings piles to be covered daily with 6 in. of nonasbestos cover or to be treated with a resinous or petroleum-based dust supressant. This alternative would eliminate visible emissions as a compliance option.

Mill tailing piles are usually large and steeply banked, making them impractical to cover and vegetate. Tailings mixed with water before being deposited on the pile form a hard crust upon drying that resists wind and water erosion. Petroleum or resinous dust-suppression agents are effective in preventing emissions from wastepiles. Mills currently comply with both the no VE and work practices provisions.

Many of the above work practices are already commonly practiced by municipal solid waste landfills. These landfills typically cover their waste, including asbestos-containing waste, daily. They segregate asbestos waste, cover it before compacting, post warning signs, and deter public access through the installation of fences. In contrast, asbestos waste disposal sites operated by plants in the asbestos industry do not always cover all of their waste on a daily basis, in particular where the waste consists of nonfriable materials such as reject brake linings and A/C products.

5.2.3.3 Cover Waste before Compaction. The current NESHAP contains no provisions that would prevent asbestos waste from being leveled and compacted without prior cover. Under this alternative, a minimum of 3 in. of nonasbestos cover would be required to be placed over asbestos waste before it could be leveled or compacted.

5.2.3.4 Require Intermediate Cover. The options under consideration include (1) no intermediate cover, (2) 12 in. of intermediate cover (6 in. in addition to 6 in. of daily cover), and (3) 18 in. of intermediate cover (12 in. in addition to 6 in. of daily cover).

5.2.3.4.1 No intermediate cover. This option would continue current practice, which is not to require an intermediate cover.

5.2.3.4.2 Intermediate cover.

- 12 in.--This option would double the thickness of soil covering asbestos-containing waste materials at disposal sites from the time they become inactive until a final cover is applied and provide one-half of the final cover thickness currently required by the asbestos NESHAP and most States.
- 18 in.--This option would treble the thickness of soil covering asbestos-containing waste materials at disposal sites from the time they become inactive until a final cover is applied and provide three-fourths of the final cover thickness currently required by the asbestos NESHAP and most States.

5.2.3.5 Require Increased Final Cover. The options under consideration include a fixed depth option and a variable depth option. The fixed depth option requires 36 in. of final cover at all inactive disposal sites. The variable depth option would require a final cover depth 12 in. greater than the frost penetration depth and in no case less than 24 in. at all inactive disposal sites. Both options would restrict the grade of the surface of the inactive site to 2 to 4 percent and require a vegetative cover except for arid regions where 3 in. of crushed rock would be accepted in lieu of vegetation.

5.2.3.5.1 Fixed depth option. Since the majority of States already require 24 in. of final cover for municipal solid waste landfills, this option would require an additional 12 in. of cover. From the standpoint of frost protection, it provides more cover than needed in the South and not enough in many northern States.

5.2.3.5.2 Variable depth option. This option would provide a final cover that is 12 in. deeper than the freezing depth, and, in no case, less than 24 in. It has the advantage of designing final cover depths that are appropriate to the climates of disposal sites while retaining the 24-in. cover where it is appropriate.

5.2.3.6 Require Covers or Enclosures for Waste Transport Vehicles. This revision would require that asbestos-containing waste material be placed in an enclosed carrying compartment of the transport vehicle or in a transport vehicle covered by a tightly fitting canvas tarp or equivalent. The existing NESHAP requires no visible emissions from waste materials or use of work practices during the collection and handling of waste in preparation for disposal at a landfill. However, the NESHAP does not include specifications regarding the transport vehicles (except for warning signs on vehicles during loading and unloading) or fiber releases that may result from spills due to shifting drums or bags, overloaded vehicles, or damage to containers that are exposed to the elements during temporary storage. Containing the waste in an enclosed carrying compartment or covering the waste with a tightly fitting cover would increase the security of the stored waste, protect the waste from the elements during temporary storage and transport, and help prevent releases from spills that may occur during transport.

Existing Federal regulations rely on the NESHAP for waste disposal provisions. The U.S. Department of Transportation has regulations governing the interstate transportation of commercial asbestos, but does not specifically address asbestos waste with the exception of container labeling. However, transporters in interstate commerce are required to report spills of 1 pound or more pursuant to the requirements of the Comprehensive Environmental Response and Compensation Liability Act (CERCLA).

5.2.3.7 Require Decontamination of Waste Hauling Vehicles. An option is being considered that would require vehicles used to haul asbestos waste to line the carrying compartment and to decontaminate the vehicle using a HEPA-filtered vacuum cleaner or clean with amended water if a spill occurs. Also, truck- or trailer-mounted vacuum systems or other holding tanks used to haul asbestos waste slurry would have to be decontaminated before being used for nonasbestos material.

5.2.3.8 Regulate Import/Export of Asbestos Waste. Possible regulatory alternatives are being explored with Office of General Counsel (OGC).

5.2.4 Spraying and Insulation

5.2.4.1 Ban Spraying. The existing standard prohibits the spraying of materials containing more than 1 percent asbestos on buildings, structures, pipes, and conduits unless the asbestos is encapsulated in a bituminous or resinous binder. Material containing more than 1 percent asbestos can be sprayed on machinery and equipment, but there most be no visible emissions or the air cleaning equipment requirements must be met.

This alternative would prohibit spraying any material that contains more than 1 percent asbestos on equipment and machinery. Materials in which the asbestos is encapsulated with a bituminous or resinous binder would continue to be exempted because they are nonfriable. Discussions with industry indicate that manufacturers have stopped the practice of adding asbestos to formulations designed for spray application. Procedures for determining the asbestos content are contained in EPA's Interim Method for the Determination of Asbestos in Bulk Insulation Samples.[13] This alternative would ensure that asbestos material will not be sprayed onto equipment and machinery where it could release fibers later during repair and maintenance activities.

5.2.4.2 Prohibit Use of Insulating Materials Containing More Than 1 Percent Asbestos. The existing NESHAP prohibits the installation or reinstallation of insulating materials containing commercial asbestos (i.e., any asbestos that is extracted from commercial ore and that has value because of its asbestos content) that are either molded and friable or wet-applied and friable after drying, except for certain spray-applied insulating materials regulated under Section 61.146. This revision would prevent the use of insulating materials that contain more than 1 percent asbestos, whether the asbestos is added as a commercial ingredient or is present in the product as a contaminant.

5.2.5 Roadways

5.2.5.1 Control Removal and Recycling of Asbestos Pavement. Under this alternative, dust suppression controls such as wetting would be required during the removal and recycling of asbestos pavement. Currently, the NESHAP contains no requirements for the removal of asbestos pavement. The manufacture of asphalt concrete with asbestos is regulated; however, this may not apply to asphalt plants that accept asbestos in recycled pavement.

5.3 REFERENCES

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6.0 ENVIRONMENTAL IMPACTS

This chapter presents the environmental impacts that will result from each of the regulatory alternatives presented in Chapter 5.0. Environmental impacts are shown for each of the sources described in Chapter 5.0. Primary impacts (impacts that result directly from the implementation of controls on pollution sources) and secondary impacts (indirect results of implementing emission controls) are discussed. Nationwide emissions estimates are presented for asbestos milling, manufacturing, and fabricating sources, as well as for demolition/ renovation operations and waste disposal. Secondary solid waste disposal impacts are also discussed.

6.1 AIR POLLUTION IMPACT

6.1.1 Milling, Manufacturing, and Fabricating--Process and Waste Disposal Emissions

Process emissions from asbestos milling, manufacturing, and fabricating are shown in Table 6-1. The emissions are based on engineering estimates described in Appendix C. The emission estimates are based on 100-percent compliance with the existing requirements although the actual degree of compliance is unverifiable because of the lack of monitoring, inspection, and recordkeeping requirements. Estimated emissions are shown for the current NESHAP and for an alternative under which high-efficiency particulate air (HEPA) filters would be added to existing air pollution control equipment. The second alternative considered for a revised NESHAP would, among other requirements, retain existing controls and require no visible emissions in addition to the air cleaning equipment specifications and no visible emissions from fugitive sources. Visual monitoring and control device inspections are already required by the NESHAP. The degree to which emissions under the second alternative would be reduced cannot generally be quantified.

TABLE 6-1. NATIONWIDE ASBESTOS EMISSIONS FROM MILLING, MANUFACTURING, AND FABRICATING, 1989 (kg/yr)

Source category	Current NESHAP	HEPA filter
Milling	329	0.96
Manufacturing		
Friction	494	0.151
A/C pipe	36	0.011
A/C sheet	26	0.008
Paper	8	0.003
Coatings, sealants	17	0.006
Plastics	34	0.010
Textiles	3	0.001
Packings, gaskets	1	0.001
V/A tile	8	0.003
Fabricating	63	0.014
Total	1,019	0.30

A/C = asbestos/cement.
V/A = vinyl/asbestos.

However, it is expected that this alternative would lead to reduced emissions at the few facilities still not in compliance and help ensure that facilities remain in compliance. For facilities using scrubbers, an aggregate reduction of 133 kg/yr (296 lb/yr) would be expected if all facilities improved their equipment to an efficiency level of 99 percent.

Table 6-2 presents estimated emissions under the current NESHAP for disposal of asbestos waste from milling, manufacturing, and fabricating sources. Appendix C describes the method of calculation. Under the option that would require HEPA filters, waste disposal emissions would not change from emissions under the current NESHAP as a result of existing waste disposal practices.

6.1.2 Demolition and Renovation

Regulatory options considered for demolition and renovation affect primarily the removal requirements; they also affect the disposal of demolition and renovation waste. Because removal and waste disposal are intimately tied to one another, their impacts are considered consecutively. Alternatives considered include requiring:

- The use of amended water
- Negative pressure and HEPA filter for all removals
- The use of the current NESHAP
- Expanded coverage of work practices and other procedures to promote emission reductions.

Table 6-3 lists the alternatives that affect emissions from demolition and renovation and from their wastes. Table 6-4 compares annual emissions from asbestos removal in demolition and renovation under the "amended water" and "negative pressure and HEPA filter" alternatives to those under the current NESHAP at full compliance and at current practice.

The "delete threshold" alternative would increase by an estimated 64 percent the number of demolition and renovation jobs covered by the regulation. Emissions of asbestos subject to the NESHAP would not increase by the same percent, however, because the additional demolitions and renovations covered would be small structures with correspondingly small quantities of asbestos. Assuming coverage is expanded to 64 percent more demolitions and renovations, emissions from removal would be reduced by an estimated 5 kg/yr (11 lb/yr), i.e., from a current level of about 12 kg/yr (27 lb/yr) to approximately 7 kg/yr (16 lb/yr).

TABLE 6-2. WASTE DISPOSAL EMISSIONS FOR MILLING, MANUFACTURING AND FABRICATING, 1989[a] (kg/yr)

Source	Emissions
Milling	22
Manufacturing	
Friction	7.4
A/C pipe	0.7
A/C sheet	0.6
Paper	0.1
Coatings, sealants	0.1
Plastics	0.4
Textiles	0.1
Packings, gaskets	0.03
V/A tile[b]	0.1
Other	0.01
Fabricating	0.4
Total	32

[a]Emissions are based on engineering estimates described in Appendix C.
[b]This product is not to be manufactured after August 1990.

TABLE 6-3. REGULATORY ALTERNATIVES THAT AFFECT DEMOLITION AND RENOVATION AND THEIR WASTE DISPOSAL

1. Threshold for applicability of work practices
2. Use of wetting agents
3. Negative pressure/HEPA filter systems
4. Regulation of all inactive disposal sites
5. Work practices at disposal sites
6. Covering waste before compaction
7. Use of intermediate cover
8. Temporary waste storage
9. Work practices for waste handling
10. Procedures for handling and disposing of bulk waste
11. Use of enclosed/covered waste transport vehicles
12. Decontamination of waste hauling vehicles
13. Regulation of nonfriable material
14. Definition of adequacy of removal operation
15. Controlling runoff from wetting and showers

TABLE 6-4. ESTIMATED NATIONWIDE ASBESTOS EMISSIONS FROM DEMOLITION AND RENOVATION, 1989 (kg/yr)

	Asbestos removal		Waste disposal	
Level of control	Demolition	Renovation	Demolition	Renovation
Current NESHAP (full compliance)	65	542	0.7	2.3
Current NESHAP (current practice)	85	744	470	3,084
Amended water	39	237	0.7	2.3
Negative pressure and HEPA filters	0.5	4	0.7	2.3
Amended water, negative pressure and HEPA, all removals	0.3	2	0.7	2.3

6.1.3 Waste Disposal

Estimated annual asbestos emissions from waste disposal from demolition and renovation activities also are given in Table 6-4 under the current NESHAP at full compliance and at current practice. The method of calculation is given in Appendix C.

The "delete threshold" alternative would be expected to decrease waste disposal emissions by an amount much less than the expected 64 percent increase in the numbers of demolitions and renovations covered by the regulation. Assuming coverage would be expanded by 64 percent, waste disposal emissions would be reduced by about 300 kg/yr (667 lb/yr) if all subthreshold structures are regulated under the NESHAP and are in full compliance.

Many of the alternatives listed in Table 6-3 are intended to codify current good work practices, and the resulting impact on emissions is not expected to be great. Because of this and because information necessary to estimate emissions are lacking, emissions were not estimated for several of these alternatives.

6.2 OTHER IMPACTS

A discussion of secondary impacts will be added at a later time.

7.0 COSTS ANALYSIS OF REGULATORY ALTERNATIVES

This chapter presents estimates of the costs that would be incurred by industries complying with each of the regulatory alternatives under consideration by EPA as potential revisions to the asbestos NESHAP. A model plant approach is used in the cost analyses.

7.1 INTRODUCTION AND SCOPE

During the review of a NESHAP, EPA performs an analysis of each regulatory alternative under consideration. A critical input to this analysis is an accurate definition of the activities that an industry would be required to undertake to comply with each alternative and an estimate of the cost of these compliance activities. The following sections present compliance activities and incremental costs that would be incurred by each of the model plants (presented in Chapter 5.0) complying with each of the regulatory alternatives (also presented in Chapter 5.0). This incremental cost is input to the economic impact analysis of regulatory alternatives that appear to have significant costs. Incremental costs due to the NESHAP may be affected by other Federal, State, and local regulations.

7.2 INCREMENTAL COSTS OF REGULATORY ALTERNATIVES

7.2.1 Milling, Manufacturing, and Fabricating

7.2.1.1 HEPA Filters. This option would require that HEPA filters be used as final filters on all exhaust airstreams from milling, manufacturing, and fabricating operations. Typically, HEPA filters would be added on to baghouses, the principal control device used in asbestos milling, manufacturing, and fabricating.

The cost of complying with this alternative was estimated as the cost of installing, operating, and maintaining HEPA filters and prefilters on the exhaust streams from all baghouses at the model plants. Unit costs for installation and periodic replacement of the filters were obtained from established vendors of the equipment for inclusion in a previous document[1] and revised to the first quarter of 1990 by means of the Chemical Engineering cost index. Annual operating cost was estimated as the increased air-pumping cost that would be brought about by the increase in system pressure drop imposed by the HEPA filters. The increase was estimated to average about 2 in. water gauge. Filter replacement costs are also an important cost factor because of the frequency with which filters must be changed. Capital and annual unit costs for HEPA filters are presented in Table 7-1. Table 7-2 presents the estimated total installed capital cost and total annualized cost of adding HEPA filters at each of the model milling, manufacturing, and fabricating plants.

A variation of this option would be to require HEPA filters as the final element of all air-cleaning devices for any new or modified facilities, but to require continuous opacity monitoring for each existing baghouse. Total capital cost of an EPA compliance monitor would be $24,400, including a purchase price of $17,500 and $6,900 for installation, certification, taxes, shipping, training, and startup. Annualized cost, for an equipment life of 5 years and an interest rate of 10 percent, and including overheads, taxes, and insurance, would be $8,218. Table 7-3 presents the estimated additional installed capital cost and annualized cost for adding continuous opacity monitors to each baghouse at each of the model milling, manufacturing, and fabricating plants.

7.2.1.2 Comply With No Visible Emissions and Equipment Specifications. Most existing plants are controlled by baghouses. These plants are not expected to require additional cost to meet a no visible emissions requirement combined with equipment specifications. However, some plants are equipped with scrubbers that would require improvement or replacement to produce no visible emissions. Using confidential data from TSCA section 8(a), the aggregate number of scrubbers in use was extracted, and annualized costs for renovating or replacing them were calculated.[2] These costs were adjusted for reduced asbestos consumption in the United States. First quarter 1990 costs, on an annualized basis, are estimated at $376,000/yr.

TABLE 7-1. COST ELEMENTS AND UNIT COSTS FOR HEPA FILTERS FOR MILLING, MANUFACTURING, AND FABRICATING

Cost element	Unit cost ($/acf)
Capital cost	
HEPA filter installation	1.32
Prefilter installation	0.20
Total	1.52
Annual cost	
HEPA filter maintenance, capital recovery, and electricity	1.28
Prefilter maintenance, capital recovery, and electricity	0.65
Prefilter replacement	2.79
Total	4.72

Note: Based on grain loading of 0.05 grain/ft^3. HEPA filters changed twice annually.

TABLE 7-2. HEPA FILTER COSTS

Model type	Exhaust volume (cfm)	Capital cost ($)	Annual cost ($)
Dry process mill	530,000	805,600	2,501,600
Wet process mill	90,000	136,800	424,800
Typical paper plant	6,000	9,120	28,320
Large friction plant	332,500	505,400	1,569,400
Typical friction plant	202,500	307,800	955,800
Small friction plant	137,500	209,000	649,000
A/C pipe plant	170,000	258,400	802,400
A/C sheet plant	145,000	220,400	684,400
Typical V/A floor tile plant	150,000	228,000	708,000
Small V/A floor tile plant	50,000	76,000	236,000
Typical plastics plant	80,000	121,600	377,600
Small plastic plant	25,000	38,000	118,000
Coatings and sealants plant	10,000	15,200	47,200
Gaskets and packings plant	115,000	174,800	542,800
Textile plant	95,000	144,400	448,400
Chlorine plant	1,200	1,824	5,664
Asphalt concrete plant	42,000	63,840	198,240
Brake shoe rebuilding plant	7,000	10,640	33,040
A/C product fabricator	19,000	28,880	89,680
Asbestos board fabricator	11,000	16,720	51,920

A/C = asbestos/cement.
V/A = vinyl/asbestos.

TABLE 7-3. CONTINUOUS OPACITY MONITOR COSTS

Model type	Number of baghouses	Capital cost ($)	Annual cost ($)
Dry process mill	4	97,600	32,870
Wet process mill	6	146,400	49,310
Typical paper plant	4	97,600	32,870
Large friction plant	26	634,400	213,700
Typical friction plant	16	390,400	131,500
Small friction plant	11	268,400	90,400
A/C pipe plant	6	146,400	49,310
A/C sheet plant	12	292,800	98,620
Typical V/A floor tile plant	3	73,200	24,650
Small V/A floor tile plant	1	24,400	8,218
Typical plastics plant	4	97,600	32,870
Small plastics plant	1	24,400	8,218
Coatings and sealants plant	5	122,000	41,090
Gaskets and packings plant	4	97,600	32,870
Textile plant	6	146,400	49,310
Chlorine plant	1	24,400	8,218
Asphalt concrete plant	1	24,400	8,218
Brake shoe rebuilding plant	1	24,400	8,218
A/C product fabricator	1	24,400	8,218
Asbestos board fabricator	1	24,400	8,218

7.2.1.3 Shutdown and Repair of Malfunctions. Although the current NESHAP does not explicitly require the shutdown and repair of malfunctioning control devices, telephone contacts with nine asbestos milling and manufacturing plants indicate that this is current industry practice.[3] Each of the plants indicated that malfunctions resulting in increased emissions are detected by the presence of visible emissions, by pressure drop changes, and by bag inspection. All of the plants shut down immediately for corrective action when a malfunction is detected. Corrective action consists of replacement of defective bags. Frequently, an entire compartment or several bags surrounding the failed bag are changed. Because the immediate shutdown and repair of a malfunctioning control device and the associated process is currently practiced, no additional control costs are associated with this regulatory alternative.

7.2.1.4 Eliminate No Visible Emissions as an Option and Require Work Practices in Waste Handling. Current milling, manufacturing, and fabricating operations comply with the work practices for waste handling. Asbestos waste from control devices typically is mixed with water or a dust suppressant before or while it is being placed in labeled leak-tight bags or containers. Nonfriable waste is often placed in leak-tight, covered dumpster until taken to the disposal site. Therefore, little or no additional cost is expected to result from this alternative.

7.2.2 Demolition Renovation

7.2.2.1 Reduce Threshold for Work Practices. Because Occupational Safety and Health Administration (OSHA) rules cover all renovations involving asbestos without regard to the amount of asbestos being removed, there would be no cost for the additional renovations resulting from deleting the threshold. On the other hand, because the NESHAP would require removal of asbestos prior to demolition (the OSHA rule does not require removal prior to demolition), there would be a cost for complying with work practices at the additional demolitions that would be covered if the threshold were deleted.

In 1987, EPA estimated the cost of removal and disposal of 80 ft^2 of in-place asbestos material. Assuming that it would take two workers (at $25/hr each) 3 days to set up, remove the asbestos, clean up, and decommission the removal site, and that the disposal cost would be $300, the total cost would be \$1,500 per job.[4] Indexed to 1990 using the Chemical Engineering cost index, the cost is \$1,500 (354.7 ÷ 323.8) = \$1,643.

For the alternatives that require notification, an industry cost of \$50 per notification is assumed.[5]

Agency burden for reviewing notifications is estimated as 0.5/hr/notification x \$14.50/hr for an employee at Grade 10, Step 7 + \$14.50 x 110 percent overhead = \$15.23/notification.

7.2.2.2 Procedures for Identifying Non-notifiers. Because a cooperative effort on the part of air pollution control and building code enforcement agencies is expected to be the preferred means of improving compliance with notification requirements, no costs would be associated with this alternative.

7.2.2.3 Require Use of Wetting Agents. The costs of wetting agents ranges from \$3.50/gal to \$15.65/gal;[6] the average cost was estimated to be \$9.58/gal. One supplier of wetting agents recommends a concentration of 1 to 3 oz of their product in 5 gal of water, and a rate of application of 100 to 150 gal of amended water per 1,000 ft^2 of asbestos for thicknesses of up to 1 in.[7] At an application rate of 100 gal/1,000 ft^2, the quantity of wetting agent required per square foot of asbestos is calculated as follows:

$$\frac{3\text{ oz}}{5\text{ gal }H_2O} \times \frac{100\text{ gal }H_2O}{1{,}000\text{ ft}^2} = 0.06\text{ ox/ft}^2 .$$

At an application rate of 150 gal/1,000 ft^2, the quantity of wetting agent required per square foot of asbestos is calculated as follows:

$$\frac{3\text{ oz}}{5\text{ gal }H_2O} \times \frac{150\text{ gal }H_2O}{1{,}000\text{ ft}^2} = 0.09\text{ oz/ft}^2 .$$

Another source indicated that 1 gal of wetting agent was required for every 1,500 ft of asbestos.[8] At this rate, the quantity of wetting agent required per square foot is

$$1\text{ gal / }1{,}500\text{ ft}^2 \times 128\text{ oz/gal} = 0.09\text{ oz/ft}^2 .$$

For purposes of estimating the quantity of wetting agent required, 0.09 oz/ft^2 is used. The cost of wetting agent per square foot of asbestos removed is calculated as follows:

$$\text{Wetting agent unit cost } (\$/ft^2) = \$0.0902/ft^2 \times 1 \text{ gal}/128 \text{ oz} \times \$9.58/\text{gal} = \$0.0067/ft^2$$

Costs of wetting agents for each of the model plants are presented in Table 7-4.

7.2.2.4 Require Use of Negative Pressure/HEPA Filter Systems. Costs associated with negative pressure/HEPA filter systems include installing and operating a unit, or units, to maintain the work area under negative pressure while air exhausted out of the work area is cleaned by a HEPA filter system. These costs are estimated from an EPA report.[9] Also included are the costs of sealing the work area or constructing an enclosure, generally of polyethylene plastic sheeting attached to an existing structure and/or to a temporary framework. Types of enclosures are divided into two parts: inexpensive or partial enclosures and expensive or full enclosures. The cost of inexpensive enclosures was developed from cost-estimating guidelines used by the Naval Facilities Engineering Command (NAVFAC) and represents the cost of materials and labor necessary to seal all exterior openings in an area. Expensive enclosure costs were estimated using information provided by members of the National Association of Demolition Contractors (NADC). These costs represent the materials and labor necessary to cover all walls and floors with a double layer of plastic (with airlocks on all passageways) and include the cost of removing and disposing of the plastic and decontaminating the area by a triple wet wipedown of all surfaces. This procedure, although not required by existing regulations, is commonly practiced by contractors involved in asbestos removal work, particularly asbestos abatement work in schools and other occupied structures. The EPA's guidelines recommend similar procedures.[10] The NADC cost estimate is in agreement with estimates contained in a research report dealing with asbestos removal projects.[11]

Cost for the exhaust units is $\$0.066/ft^2$. Costs for the inexpensive enclosures are $\$0.23/ft^2$, and costs for the expensive enclosures are $\$3.85/ft^2$. These costs, revised from 1984 estimates and applied to the model plants described in Chapter 5.0, are given in Table 7-5. These costs are associated with asbestos removal prior to demolition (the OSHA rule does not require removal prior to demolition). OSHA rules would already require the use of negative pressure/HEPA filter systems in renovations.

TABLE 7-4. MODEL PLANT COSTS OF USING WETTING AGENTS

	Amount (ft^2) of asbestos		Cost ($) of wetting agent	
Model type	Demolition	Renovation	Demolition	Renovation
5-unit apartment	8,130	7,500	55	51
50-unit apartment	91,310	50,000	615	337
Small school	44,766	43,200	302	291
Medium school	203,302	111,100	1,369	748
Large school	447,811	245,000	3,016	1,650
Cargo ship	70,000	--	472	--
Cruise ship	--	700	--	5
Small hospital	1,814	213	12	1
Medium hospital	105,499	629	710	4
Large hospital	91,550	1,649	617	11
Small hotel	4,893	2,557	33	17
Large hotel	180,590	4,222	1,216	28
Small office building	7,688	7,200	52	48
Medium office building	37,425	36,000	252	2
Large office building	515,288	288,000	3,471	1,940
Department store	1,243	398	8	3
Small grocery	323	213	2	1
Small industrial boiler	2,814	1,736	19	12
Medium industrial boiler	16,335	10,755	110	72
Small refinery	1,001,924	3,142	6,749	21
Medium refinery	3,638,491	3,142	24,509	21
Small power plant	4,957	132	33	1
Medium power plant	109,748	9,766	739	5
Single-unit dwelling				
Model A	213	72	1	<1
Model B	325	213	2	1
Model C	2,685	1,288	18	9

TABLE 7-5. NEGATIVE PRESSURE SYSTEM COSTS

Model type	Floor area (ft^2)	Enclosure cost ($)	Filter unit cost ($)	Total cost ($)
Small school	43,200	9,936	2,851	12,787
Medium school	122,800	28,244	7,368	35,612
Large school	271,000	62,330	16,260	78,590
Large hotel	221,184	50,872	13,271	64,143
Small hotel	69,320	15,944	4,159	20,103
Small grocery	2,800	644	168	812
Medium dept. store	65,700	15,111	3,942	19,053
5-family apt.	8,250	1,898	495	2,393
50-family apt.	50,000	11,500	3,000	14,500
Single-unit dwelling	1,288	296	77	374
Small office bldg.	7,200	1,656	432	2,088
Medium office bldg.	36,000	8,280	2,160	10,440
Large office bldg.	288,000	66,240	17,280	83,520
Small hospital	14,400	3,312	864	4,176
Medium hospital	60,000	13,800	3,600	17,400
Large hospital	316,000	72,680	18,960	91,640
Small industrial bldg.	7,000	1,610	420	2,030
Medium industrial bldg.	14,000	3,220	840	4,060
Small power plant	12,417	2,856	745	3,601
Medium power plant	174,900	40,227	10,494	50,721
Small industrial blr.	633	146	38	184
Medium industrial blr.	1,600	368	96	464
Small refinery	1,179,000	271,170	70,740	341,910
Medium refinery	4,554,000	1,047,420	273,240	1,320,660
Cruise ship	700	161	42	203
Cargo ship	100,000	23,000	6,000	29,000

7.2.2.5. Require Training of Owners, Inspectors, and Workers.

7.2.2.5.1 Abatement workers. For initial training, it is estimated that abatement workers would be required to attend a training course of 1 day, or 8 hr. A 1-day course is estimated to cost about $140. Additional costs that would be incurred include the cost of paying the worker while attending the course and traveling to and from the course (12 hr x $22.21/hr* = $267), the cost of travel to and from the course (100 miles x $0.25/mile = $25), the cost of overnight lodging and meals ($100), and the certification examination fee ($75). The total cost of the initial training for abatement workers is as follows:

Training course	$140
Worker's time	267
Travel	25
Lodging and meals	100
Certification examination	75
Total	$607

The cost of annual refresher training includes the cost of a one-half day course ($90), the worker's time (8 hr x $22.21/hr = $178), travel ($25), and meals ($25). Thus, the total cost for annual refresher training is as follows:

Training course	$ 90
Worker's time	178
Travel	25
Meals	25
Total	$318

The number of abatement workers who would have to be trained is difficult to estimate. An estimated 45,575 to 60,515 abatement workers are involved in asbestos abatement work annually.[13] Under the training requirements for the Asbestos Hazard and Emergency Response Act (AHERA), abatement workers performing asbestos abatement work in schools must be trained and certified. The training requirements under AHERA would satisfy the NESHAP training requirements. Therefore, it would appear that a significant portion of abatement workers would have already been trained.

*Hourly rate for abatement workers based on weighted average of median weekly earnings for male and female construction worker plus 27.3 percent for fringe benefits and 60 percent for overhead.[12]

However, as a result of high turnover rates among asbestos workers (26 percent,[14]) movement of workers in and out of asbestos-related construction jobs, and difficulty in establishing proof of previous training, the number of workers that would require training under the NESHAP is difficult to estimate accurately. For purposes of this analysis, the number is estimated to be close to the total number of asbestos abatement workers (45,575 to 60,515). The number of workers requiring annual refresher training is also difficult to determine and, for simplicity, is assumed to be 45,575 to 60,515. The number of workers and cost per trainee are summarized in Table 7-6.

7.2.2.5.2 Building owners/operators. For initial training, building owners or operators, or their representatives, are expected to attend a 4-hr course costing $90. Additional costs will be incurred for the owner/operators time (8 hr x $32.40*/hr = $259), travel ($25), and meals ($25). Total cost is as follows:

Training course	$ 90
Owner/operator's time	259
Travel	25
Meals	25
Total	$399

The building owner/operator, or his representative, will attend a 2-hr refresher training course annually at a cost of $50. Additional costs include the owner/operator's time (6 hr x $32.40/hr = $194), travel ($25), and meals ($15). Total refresher training cost would be as follows:

Training course	$ 50
Owner/operator's time	194
Travel	25
Meals	15
Total	$284

Regarding the number of owners/operators as of 1989, there were 3,326,896 buildings in the United States built prior to 1979 according to a recent EPA report.[16] The EPA estimates that 20 percent of these buildings contain asbestos material.[17] Therefore, the number of buildings containing

*An hourly rate of $15.90 was used and is based on average of median weekly earning for male and female administrative and managerial occupations. To that was added 60 percent for overhead and 27.3 percent for benefits.[15]

TABLE 7-6. NUMBER OF ASBESTOS WORKERS, INSPECTORS, AND BUILDING OWNERS TO BE TRAINED AND COSTS

	Number to be trained		Training costs per trainee ($)	
	Low	High	Initial	Refresher (annually)
Asbestos workers	45,575	60,515	607	318
Asbestos inspectors	7,000		724	396
Building owners	665,379	3,326,896	399	284

asbestos material is 665,379.[18] For each building, it is estimated that one owner/operator, or their representative, would require training. An upper-bound estimate assumes that one individual would be trained for each of the more than 3 million buildings. This probably overstates the actual number because many of these buildings have probably been inspected and found to not contain asbestos. The owners/operators of these buildings would not require training. The number of trainees and cost per trainee are summarized in Table 7-6. A lower-bound estimate would result from the assumption that only the owners/operators of the 665,379 asbestos-containing buildings would have to be trained.

7.2.2.5.3 Asbestos inspectors. For initial training, an inspector training course is expected to be taught as an 8-hr class. It is estimated that the course fee for building inspectors would be $140 plus an exam fee of $75. Additional costs for the initial training include the inspector's time for attending the course (12 hr x $32.00/hr* = $384), travel ($25), and lodging and meals ($100). Total cost per person trained would be:

Training course	$140
Certification examination	75
Inspector's time	384
Travel	25
Lodging and meals	100
Total	$724

Asbestos inspectors would be required to attend a 4-hr refresher training course annually. The cost of the refresher course would be $90, with additional cost for the inspector's time (8 hr x $32.00/hr = $256), travel ($25), and meals ($25). Total cost per inspector would be as follows:

Training course	$ 90
Inspector's time	256
Travel	25
Meals	25
Total	$396

Regarding the number of asbestos inspectors, information is not available that permits an accurate estimate of the number of individuals

*An hourly rate of $15.71 was used and is based on average of median weekly earnings for male and female professional specialty occupation. To that was added 60 percent for overhead and 27.3 percent for benefits.[19]

that would have to be trained as asbestos inspectors. For purposes of this analysis, the number requiring training as inspectors is estimated to be approximately equal to the number of asbestos abatement contractors, about 7,000.

7.2.2.6 Specify Protocol for Bulk Sampling. Under this alternative, the collection of bulk samples to determine the presence of asbestos prior to demolition or renovation would have to adhere to a specific protocol regarding the number of samples necessary. Sampling would be done according to the AHERA protocol for collecting bulk samples. A unit cost of $60 for sampling and analysis was reported earlier and was adjusted to the first quarter of 1990 using the Chemical Engineering overall cost index. Sampling costs for structures that are going to be demolished are the same as the sampling costs reported in Subsection 7.2.2.9 (Repair and Maintenance of Asbestos on Facility Components). The number of samples required for model structures for renovation was estimated independently for each model based on the amount of asbestos affected, the presence of areas considered homogeneous, and the number of different facility components involved. Where the area of asbestos greatly exceeds 5,000 ft^2, it was assumed that more than seven samples would be required, and on average, approximately one additional sample per 1,000 ft^2 would be taken. However, when the number of samples would run into the hundreds by taking one sample per 1,000 ft^2, it was estimated that fewer samples would be taken, and areas of suspect materials that appeared similar to areas where samples were positive for asbestos would be assumed to contain asbestos.

To the extent that suspect material is known to contain asbestos or is assumed to contain asbestos, sampling costs may overstate actual costs. For example, where a previous inspection showed asbestos material present, additional sampling at the time of demolition or renovation may not be necessary. Also, if one sample is positive for asbestos, then it is not necessary to take additional samples. Table 7-7 contains the estimated costs for model plants.

7.2.2.7 Controls During Waste Handling. Under the first option, there would no longer be a choice of compliance options; work practice controls would be required, and the visible emission compliance option would be eliminated. Under the second option, compliance with work practices and no visible emissions requirements would be required. Current

TABLE 7-7. ESTIMATED BULK SAMPLING COSTS FOR RENOVATION MODELS

Model type	Amount of asbestos removed (ft^2)	Number of samples required	Cost/model ($)
Small school	43,200	43	2,838
Medium school	111,100	50	3,300
Large school 245,000	123	8,118	
Large hotel	4,222	8	528
Small hotel	2,557	8	528
Small grocery	213	6	396
Medium dept. store	398	6	396
Small indust. bldg.	1,736	8	528
Medium indust. bldg.	10,755	10	660
5-family apt.	7,500	7	462
50-family apt.	50,000	50	3,300
Small refinery	3,142	5	330
Medium refinery	3,142	5	330
Small power plant	132	6	396
Medium power plant	9,766	12	792
Single-unit dwelling	1,288	5	330
Cruise ship	700	6	396
Small office bldg.	7,200	7	462
Medium office bldg.	36,000	36	2,376
Large office bldg.	288,000	144	9,504
Small hospital	213	6	396
Medium hospital	629	6	396
Large hospital	1,649	8	528

practice at demolition and renovation sites is to wet the asbestos-containing waste and place it in leak-tight containers. Careful adherence to these work practices will usually prevent visible emissions to the outside air. Because current practices typically include use of work practices, which prevent visible emissions from occurring, little or no additional cost would be associated with either of these options.

7.2.2.8 Procedures for Handling and Disposal of Bulk Wastes. Under this alternative, bulk asbestos waste resulting from structures demolished or renovated without first removing the asbestos would have to adhere to additional work practices. For such demolitions, all waste resulting from the process would be considered as asbestos-containing material (ACM). Temporary covers would be required over wastepiles that will be left for more than 1 day or that are subject to wind gusts, and transport vehicles would have to be covered. The current NESHAP already requires that bulk waste be wetted. No information is available on the number of demolitions and renovations that would be affected by this alternative.

Costs for handling and disposing of bulk wastes are divided among work practices, temporary covers, and tarpaulins for transport vehicles. It is assumed that no additional cost will be incurred for coverage and compaction at the disposal site because it is believed that this waste is already covered on a daily basis. For work practices, it is assumed that work costs increased by 10 percent. For general demolition, Means gives a cost of $0.20/ft^3, or $7.07/ m^3.[20] Temporary covers are assumed to be polyethylene-impregnated tarpaulins at $0.06/ft^2. For a typical wastepile, this cost is equivalent to $0.03/ft^3 or $1.06/m^3. Tarpaulins for transport vehicles cost about $127 each for a 15-ft by 20-ft cover. This cost would vary depending on the number of trips that could be made before the tarpaulin became unserviceable. Assuming an average cost of $0.11/m^3 for tarpaulins, the sum of the above costs would be $8.24/m^3 for handling and disposing of bulk waste. Costs for each of the model plants are shown for demolition and renovation in Table 7-8.

7.2.2.9 Repair and Maintenance of Asbestos on Facility Components. Under this regulatory alternative, buildings would be inspected to identify damaged suspect materials and to determine if such materials contain asbestos. Removal or enclosure would be required for all damaged ACM.

TABLE 7-8. BULK WASTE HANDLING AND DISPOSAL COSTS

Model type	Demolition volume (m^3)	Renovation volume (m^3)	Demolition removal cost ($)	Renovation removal cost ($)
Small school	158	153	1,302	1,368
Medium school	1,113	393	9,171	3,513
Large school	2,490	867	20,518	7,751
Large hotel	1,487	30	12,253	268
Small hotel	513	18	4,227	161
Small grocery	3	3	25	27
Medium dept. store	6	3	49	27
5-family apt.	17	13	140	116
50-family apt.	499	89	4,112	796
Single-unit dwelling	9	4	74	36
Small office bldg.	29	26	239	232
Medium office bldg.	267	255	2,200	2,280
Large office bldg.	3,918	2,037	32,284	18,211
Small hospital	9	3	74	27
Medium hospital	1,012	11	8,339	98
Large hospital	411	23	3,387	206
Small industrial bldg.	34	28	280	250
Medium industrial bldg.	219	180	1,805	1,609
Small power plant	54	1	445	9
Medium power plant	1,996	58	16,447	519
Small refinery	13,271	22	109,353	197
Medium refinery	47,196	22	388,895	197
Cruise ship	195	15	1,607	134
Cargo ship	621	0	5,117	0

The costs associated with this regulatory alternative were estimated on the basis of unit costs reported in other literature sources. The cost of a preliminary inspection was obtained from a 1990 EPA study that reported a cost of $0.035 per square foot of building floor area as representative of current costs.[21] This value was used to estimate the inspection costs for the model buildings in this study. Costs of sampling for the presence of asbestos in friable materials and some of the costs of dealing with damaged asbestos were obtained from a 1989 EPA report to Congress, which used data from previous experience with the AHERA rule for asbestos in schools.[22] Additional data pertaining to costs and to the amount of ACM that is damaged were obtained from a report of a survey of buildings by the City of New York.[23] Sampling costs were estimated under the assumption that material in good condition would not be sampled. Only ACM having surface damage would be sampled where appropriate. For estimating sampling costs for the model buildings, data from the New York City study were used to estimate the surface area of damaged ACM by building type. This estimate was made by calculating the fraction of total ACM area that was found to be damaged in the New York City study by building type and applying that fraction to the model buildings used in the current study. The numbers of samples needed were estimated as a minimum of three for ACM area up to 10,000 ft^2 and a total of five samples for buildings where the amount of damaged ACM was greater than 10,000 ft^2 and less than 50,000 ft^2. A minimum of three samples was assumed for all buildings. At a cost of $66 per sample, a minimum sampling cost of $198 was obtained.

The costs of dealing with damaged ACM were estimated based on two different information sources, the reported costs for dealing with asbestos in schools and the range of costs reported in the New York City study. The weighted average cost of dealing with asbestos in schools was estimated based on the distribution of types of actions taken in schools. This cost came out to be $3.45/$ft^2$. Data reported in the New York City study indicated a cost range of $4.00/$ft^2$ to $20.00/$ft^2$ for removing asbestos. In the New York City study, a cost of $20.00/$ft^2$ was used to estimate the cost of removing asbestos, but the authors of the report stated that these costs were significantly higher than in other parts of the country. In light of this statement and considering the average costs reported for schools, a removal cost of $\$10.00/ft^2$ was selected as a reasonable, midpoint approximation of average nationwide costs. Similarly, the cost for replacing the removed material was also estimated at $\$10.00/ft^2$. Replacement cost was estimated at $\$20.00/ft^2$ in the New York City study. The R.S. Means Construction Cost Manual lists costs of up to $\$15.00/ft^2$ for replacement costs[24] (the previous estimates based on industry contacts were in the range of $\$2.00/ft^2$). Considering this variation in costs, $\$10.00/ft^2$ was selected as a reasonable, midpoint value to use in estimating nationwide costs for this regulatory option. The costs of enclosure of ACM was estimated in the New York City study at $\$8.00/ft^2$ and was reported as approximately $\$4.00/ft^2$ for schools. Using these values as a basis, an average cost of $\$6.00/ft^2$ was used to estimate enclosure costs for this regulatory option.

For costing purposes, the area of damaged ACM was estimated using the same assumptions that were used to estimate costs in the New York City study. In the building survey for that study, damaged ACM was classified as either being in poor condition or in fair condition. Poor condition was defined as having more than 10 percent of the surface area damaged, and fair condition was defined as having less than 10 percent of the surface area damaged. Costs were estimated by assuming that 25 percent of the ACM in poor condition would be removed and the other 75 percent would be enclosed. For material in fair condition, it was assumed that 10 percent of the ACM would be enclosed. The costs of sampling and analysis, which were previously reported as \$60/sample, were adjusted to the first quarter of 1990 using the Chemical Engineering overall cost index to obtain a value of \$66/sample.

Table 7-9 shows the percentage of surfacing and thermal ACM that was in poor and fair condition in the New York City study.[25] These values were used to estimate the amount of ACM that would be removed and the amount that would be enclosed for each of the model plants. The final column in the table shows the area used as a basis for estimating sampling costs. This value is equal to 25 percent of the ACM in poor condition and 10 percent of the ACM in fair condition. Table 7-10 presents a summary of the estimated costs for each of the model buildings used in this study.

7.2.2.10 Procedures for Nonfriable Material. This alternative would require Category I nonfriable ACM (nonfriable resilient floor covering,

TABLE 7-9. AMOUNT OF ACM IN POOR AND FAIR CONDITION AND AREA SAMPLED

Model type	Surfacing ACM (%) Poor condition	Surfacing ACM (%) Fair condition	Thermal ACM (%) Poor condition	Thermal ACM (%) Fair condition	Surface area sampled (ft^2)
Small school	0	97	12	59	4,463
Medium school	0	97	12	59	20,010
Large school	0	97	12	59	43,992
Small hotel	1	58	33	39	951
Large hotel	1	58	33	39	14,080
Small grocery	0	100	25	63	79
Medium dept. store	0	100	25	63	355
Small indust. bldg.	100	0	35	50	2,154
Medium indust. bldg.	100	0	35	50	12,942
5-family apt.	0	0	33	61	194
50-family apt.	0	0	11	80	432
Single-unit dwelling	0	0	21	59	38
Small office bldg.	0.5	11	22	58	225
Medium office bldg.	0.5	11	22	58	894
Large office bldg.	1	73	28	57	44,671
Small hospital	1	58	33	39	398
Medium hospital	1	58	33	39	9,356
Large hospital	1	58	33	39	22,073

SOURCE: Westat, Inc. Assessment of the Public's Risk of Exposure to In-Place Asbestos. Final Report. Prepared for City of New York, NY. December 1, 1988.

TABLE 7-10. ASBESTOS INSPECTION AND MAINTENANCE COST ESTIMATES

Model type	Floor area (ft^2)	Sprayed or trowelled-on ACFM area (ft^2)	Thermal system ACFM area (ft^2)	Inspection cost ($)	Sampling cost ($)	Sprayed or trowelled-on maintenance cost	Thermal system maintenance cost ($)
Small school	43,200	43,300	1,466	1,512	198	25,201	2,190
Medium school	122,800	199,763	3,539	4,298	330	116,262	5,287
Large school	271,000	441,050	6,761	9,485	330	256,691	10,101
Small hotel	69,320	2,840	2,053	2,426	198	1,258	6,917
Large hotel	221,184	174,610	5,980	7,741	330	77,352	20,147
Small grocery	2,800	100	222	98	198	60	611
Medium dept. store	65,700	160	1,083	2,300	198	96	2,981
Small indust. bldg.	7,000	1,714	1,100	245	198	16,283	3,988
Medium indust. bldg.	14,000	10,680	5,655	490	330	101,460	20, 499
5-family apt.	8,250	7,635	495	289	198	0	1,733
50-family apt.	50,000	89,037	2,273	1,750	198	0	3,466
Single-unit dwelling	1,288	1,360	141	45	198	0	331
Small office bldg.	7,200	7,300	388	252	198	829	946
Medium office bldg.	36,000	36,300	1,125	1,260	198	4,120	2,743
Large office bldg.	288,000	507,800	7,488	10,080	330	270,657	22,479
Small hospital	14,400	900	914	504	198	399	3,079
Medium hospital	60,000	98,250	7,249	2,100	$198	43,525	24,422
Large hospital	316,000	38,900	52,900	11,060	$330	17,233	177,378

Notes:

Maintenance cost is $10.00/ft^2 for removal of damaged ACM.

Replacement cost is $10.00/ft^2

Inspection cost is $0.035/ft^2 of floor area.

Bulk sampling cost is $66.00/sample, including sample collection and analysis.

Reinspection cost is $48 or $80 depending on building complexity.

asphalt roofing products, gaskets, and packing) to be removed prior to demolition and disposed of in a landfill operated according to the NESHAP. Currently, the NESHAP does not require Category I ACM to be removed prior to demolition. Category I nonfriable ACM that is heavily damaged by sanding, grinding, cutting, or abrading is currently covered by the NESHAP as is the waste from such operations.

Also, under this alternative, Category I nonfriable ACM and Category II nonfriable ACM (nonfriable materials other than Category I materials, which include asbestos-cement products) that are removed as part of demolition or renovation without being significantly damaged would be required to be disposed of in a NESHAP-acceptable landfill. This is not required under the current NESHAP, which requires removal of Category II material prior to demolition.

Under this alternative, additional costs would be incurred for the following operations:

- Removal of nonfriable Category I ACM prior to demolition--cost would be incurred for wetting, removal, and disposal
- Disposal in a NESHAP landfill of nonfriable Category I and Category II ACM that was not crumbled, pulverized, or reduced to powder, i.e., material in good condition.

Little information is available on the presence of nonfriable asbestos materials in buildings. An estimated 1,526,000 buildings (42 percent), in a building survey of 3,600,000 buildings, were known to contain asbestos containing floor tile.[26] No other information is available on the amounts of other types of nonfriable asbestos-containing materials contained in buildings.

Using R.S. Means Construction Cost Data, two workers can remove 1,000 ft^2 of floor tile in 8 hr at a unit cost for removal $0.42/$ft^2$.[27] For built-up roofing, data from R.S. Means Construction Cost Data also indicate that a crew of four laborers and one foreman can remove 1,600 ft^2/day at a unit cost of $0.67/$ft^2$. The cost of using wetting agent is estimated to be $0.0067/$ft^2$. A previous cost for asbestos waste disposal of $162/$yd^3$ was adjusted using Chemical Engineering cost factors to $181/$yd^3$. Model plant costs for the removal and disposal of nonfriable materials are shown in Table 7-11.

TABLE 7-11. COST OF REMOVING AND DISPOSING OF NONFRIABLE ASBESTOS

Model type	Asbestos removal (ft^2)	Waste generated (yd^3)	Cost			
			Wetting	Removal	Disposal	Total
Apartment bldg. containing vinyl floor tile						
Demolition	7,500	4.3	50	3,150	778	3,978
Renovation	2,500	1.4	17	1,050	253	1,320
Industrial bldg. containing A/C sheet						
Removal	24,750	57.3	NA	NA	10,371	10,371
Apartment bldg. containing built-up roofing						
Removal	2,500	69.4	17	1,675	12,561	14,253

7.2.2.11 Specifications for Determining Adequacy of Removals. The costs associated with the adequacy of removals requirements were estimated by applying unit costs to the model operations presented in Chapter 5.0. Table 7-12 presents the unit costs for each of the two adequacy of removal options.

Estimates of the labor required per square foot of surface area for postabatement HEPA vacuuming and wet cleaning were derived from information in a recent OTS report and from R.S. Means asbestos removal cost factors.[34,35] Average labor requirements for each cleanup task were developed. The unit cost for one postabatement cleaning including HEPA vacuuming and wet cleaning was then estimated using the unit cost of an asbestos crew from R. S. Means[36] and the estimated average labor requirement.

The source of the sampling unit cost was the OTS report that contained information on the labor required for postabatement cleaning.[37] A sampling time of 3 hr was estimated using specifications from Appendix A on the interim transmission electron microscopy (TEM) analytical method and field sampling protocol for the clearance testing of an abatement site of the AHERA proposal.[38] Therefore, the cost of sampling was estimated as $180/sample. The TEM analysis cost is the cost published in the fee schedule of an environmental consulting firm and represents the routine analysis of a 10-sample set with blanks.[39] Visual inspection costs were estimated using a unit cost of 3.5 ¢/ft^2 from a recent OTS report.[40] This cost was based on information from EPA asbestos program managers.

Table 7-13 presents the estimated costs of the adequacy of removals requirements for each model demolition and renovation operation with the exception of the model schools. Only demolition operation costs are presented for model schools because school renovation operations would be subject to the AHERA clearance monitoring requirements that served as the basis for the NESHAP regulatory alternative.

The Option I adequacy of removals costs represent the cost of postabatement double-cleaning of all surfaces followed by a visual inspection. Each cleaning would include the use of HEPA vacuums followed by wet methods with amended water. The second cleaning would be performed 24 hr after the first cleaning. The adequacy of removal costs for Option II includes the

TABLE 7-12. ADEQUACY OF REMOVAL UNIT COSTS

Cost element	Unit cost	Source
Postabatement cleaning with HEPA vacuum and water	\$35.88/100 ft^2 of surface/ cleaning	28, 29, 30
Sampling	\$60/hr	31
Transmission electron microscopy	\$2,700/10 sample set (with blanks)	32
Visual inspection	\$0.035/ft^2 of cleaned surface	33

Sources: Research Triangle Institute. Asbestos Abatement Rules: A Preliminary Cost-Effectiveness Analysis. Prepared for U.S. Environmental Protection Agency, Office of Toxic Substances. Washington, DC. July 1985. p. B-11.

R.S. Means Company, Inc. Means Construction Cost Data 1990 (48th annual edition). R.S. Means Co., Inc. Kingston, MA. 1989. p. 31.

R.S. Means Company, Inc. Means Construction Cost Data 1990 (48th annual edition). R.S. Means Co., Inc. Kingston, MA. 1989. p. vi.

Research Triangle Institute. Asbestos Abatement Rules: A Preliminary Cost-Effectiveness Analysis. Prepared for U.S. Environmental Protection Agency, Office of Toxic Substances. Washington, DC. July 1985. p. B-10.

Clayton Environmental Consultants. Microscopy Services for Analysis of Asbestos-Fee Schedule. April 1989.

Muehling, B., and J. Parker. Economic Analysis of the Cost of an Hypothetical EPA Asbestos Inspection Rule. U.S. Environmental Protection Agency, Office of Toxic Substances. Washington, DC. March 1990.

TABLE 7-13. COSTS OF ADEQUACY OF REMOVALS REQUIREMENTS

Model type	Area of facility components to be cleaned (ft^2)		Costs ($)			
			Option I[a]		Option II[b]	
	Demolition	Renovation	Demolition	Renovation	Demolition	Renovation
Small school	43,857	NA	17,200	0	21,700	0
Medium school	157,252	NA	61,900	0	79,900	0
Large school	347,411	NA	137,000	0	160,000	0
Large hotel	121,492	4,033	47,900	1,590	106,000	6,090
Small hotel	3,647	2,494	1,440	982	28,400	5,480
Small grocery	213	177	83	70	4,580	4,570
Medium department store	416	529	164	102	13,700	4,600
5-family apartment	7,763	7,500	3,060	2,950	21,100	21,000
50-family apartment	74,692	50,000	29,400	19,700	78,900	69,200
Small refinery[c]	624,933	1,571	246,000	619	246,000	619
Medium refinery[c]	2,172,415	1,571	855,000	619	855,000	619
Small power plant	2,601	41	1,020	16	5,520	4,520
Medium power plant	78,332	6,377	30,800	2,510	35,300	7,010
Small industrial building	2,499	16	984	7	5,480	4,510
Medium industrial building	15,392	63	6,060	25	10,600	4,530
Single-unit dwelling						
Model A	151	72	59	29	4,560	4,530
Model B	263	151	103	59	9,100	4,560
Model C	2,623	1,288	1,030	507	10,000	5,010
Small office building	7,468	7,200	2,940	2,830	11,900	7,330
Medium office building	36,761	36,000	14,500	14,200	41,500	36,700
Large office building	439,312	288,000	173,000	113,000	268,000	203,000
Small hospital	1,274	177	490	70	9,490	4,570
Medium hospital	71,542	610	28,200	240	46,200	4,740
Large hospital	7,830	191	23,300	566	59,300	5,070

[a] The adequacy of removal requirements under Option I includes double-cleaning of all surfaces with HEPA vacuum and water followed by visual inspection.
[b] The adequacy of removal requirements under Option II includes double-cleaning of all surfaces with HEPA vacuum and water, clearance air monitoring, and visual inspection.
[c] The compliance costs for Options I and II are the same because the asbestos removal is outdoors; therefore, there are no clearance air monitoring costs.

cost of postabatement double-cleaning of all surfaces, clearance monitoring, and visual inspection for each worksite. For multistoried buildings, each floor is assumed to be a separate worksite. For each worksite, five outside samples, five samples from inside the worksite, and three blanks must be analyzed. No additional costs are estimated for worksites that are not found to be sufficiently clean by the first clearance monitoring.

It should be noted that 22 States already require postabatement HEPA vacuuming and wet cleaning followed by clearance monitoring after renovation operations; two States require HEPA vacuuming and wet cleaning, but do not require clearance monitoring. In addition, the specifications for many asbestos removal jobs include postabatement cleaning and clearance monitoring requirements. Therefore, the costs associated with the renovation adequacy of removal requirements under Options I and II would only be incurred in the States with no current adequacy of removal requirements and on jobs where the adequacy of removals requirements have not been specified.

7.2.2.12 Require Viewing Ports in Enclosures. In estimating the cost of adding viewing ports to enclosures for asbestos removal projects, an assumption was made that it would not be necessary to view all parts of the work area. Sufficient visibility should be provided to allow an inspector to determine if there is a need to enter the work area to make further observations. To achieve this goal, it was estimated that at least two viewing ports would be required for each work area and at least one viewing port for boiler rooms. For projects that involve multiple stories, having at least two viewing ports per story was assumed. Each viewing port was assumed to be constructed of a 1-ft by 2-ft piece of Plexiglas with a material cost of $\$1.00/\text{ft}^2$. The installation of a viewing port, consisting of cutting out the hole in the plastic and taping the Plexiglas in place, was estimated to require two workers for 15 min or a total of 1/2 hr of labor. These factors were used to estimate the cost of adding viewing ports for each of the model buildings developed in this study. The results of the cost estimates for each model building are given in Table 7-14.

7.2.2.13 Control Runoff from Wetting and Showers. To estimate the cost associated with this alternative, it is necessary to estimate the amount of runoff from demolitions and renovations. The volume of runoff

TABLE 7-14. COSTS OF INSTALLING VIEWING PORTS IN ASBESTOS ENCLOSURES

Model type	Floor area (ft^2)	Number of viewing ports		Costs of viewing ports[a] ($)	
		Demolition	Renovation	Demolition	Renovation
Small school	43,200	3	2	39	26
Medium school	122,800	9	6	118	79
Large school	271,000	11	8	144	105
Small hotel	69,320	3	2	39	26
Large hotel	221,184	25	2	328	26
Small grocery	2,800	3	2	39	26
Medium department store	65,700	5	2	66	26
Small indust. building	7,000	2	2	26	26
Medium indust. building	14,000	2	2	26	26
5-family apartment	8,250	7	6	92	79
50-family apartment	50,000	21	20	275	262
Single-unit dwelling	1,288	2	2	26	26
Small office building	7,200	3	2	39	26
Medium office building	36,000	11	10	144	131
Large office building	288,000	42	40	550	524
Small hospital	14,400	3	2	39	26
Medium hospital	60,000	8	2	105	26
Large hospital	316,000	16	2	210	26

[a] The cost per enclosure is estimated as $2.00 for materials plus 0.5 hr of labor at $22.21/hr.

from renovations and demolitions was estimated as follows. For each of the model structures defined in Chapter 5.0, the volume and area (as a 1-in. thickness) of asbestos removed in renovations and demolitions were estimated (see Table 7-15). Next, the volume of water applied for wetting was calculated by multiplying area (ft^2) by water application rate (gal/ft^2) to obtain gallons. Water application rates for wetting range from 1 to 1.5 gal/10 ft^2, with the high end of the range used in demolitions. Application rates of 1.1 gal/10 ft^2 and 1.5 gal/10 ft^2 were assumed for renovation and demolition, respectively. Because the density of wet-segregated asbestos is about 20 lb/ft^3, approximately twice that of dry-segregated asbestos,[41] water absorbed was obtained by multiplying the volume of asbestos (ft^3) by 10 lb to obtain pounds of water absorbed and dividing by 8.341 lb/gal to obtain gallons. Potential runoff for each model plant and type of removal was given by the difference between water applied and water absorbed. Water balances for wetting by model plant are given in Tables 7-16 and 7-17 for demolition and renovation, respectively.

The numbers of filtration units required to filter runoff were estimated for demolition and renovation of each model plant on the basis of two four-man removal teams sharing one filtration unit. For model plants and removals with potential runoff of less than 500 gal, it was assumed that the water would be filtered in the decontamination shower filter. The number of four-man teams required for a removal was estimated by assuming a removal rate of 225 ft^2/man-day and representative completion times for demolitions and renovations as shown in Table 7-18.[42] The numbers of filtration units by model plant are given in Table 7-19.

The number of filters required for demolition and renovation of each model plant are also given in Table 7-19. It was assumed that a filter would be changed after one full day of service, i.e., 8 hr. Thus, the number of filters was estimated by dividing potential runoff (gal) from each removal job shown in Tables 7-16 and 7-17 by 15 gal/min filtration rate x 60 min/hr x 8 hr/workday = 7,200 gal/day of runoff filtered, and dividing that by the number of filtration units shown for each model in Table 7-19.

A 15 gal/min pump costs about \$565.00 and filters cost \$60.00 for a case containing 25 filters.[43]

TABLE 7-15. SEGREGATED ASBESTOS REMOVED FROM MODEL PLANTS

Model type	Renovations		Demolitions	
	ft^3	ft^{2a}	ft^3	ft^{2a}
5-unit apartment	153	1,837	198	2,377
50-unit apartment	1,044	12,533	5,877	70,552
Small school	1,800	21,609	1,863	22,365
Medium school	4,626	55,534	10,017	120,252
Large school	10,215	122,629	29,331	352,113
Cargo ship	--	--	7,317	87,839
Cruise ship	180	2,161	--	--
Small hospital	36	432	108	1,297
Medium hospital	126	1,513	11,916	143,049
Large hospital	270	3,241	4,842	58,127
Small hotel	216	2,593	6,039	72,497
Large hotel	351	4,214	17,514	210,252
Small office building	306	3,673	342	4,106
Medium office building	3,006	36,086	3,141	37,707
Large office building	23,994	288,043	46,152	554,046
Department store	36	432	72	864
Small grocery	36	432	36	432
Small industrial boiler	333	3,998	396	4,754
Medium industrial boiler	2,124	25,498	2,583	31,008
Small refinery	261	3,133	156,312	1,876,495
Medium refinery	261	3,133	555,903	6,673,505
Small power plant	9	108	639	7,671
Medium power plant	684	8,211	23,157	277,995
Single-unit dwelling				
Model A	27	324	36	432
Model B	36	432	45	540
Model C	45	540	108	1,297

[a]Area of asbestos at 1-in. thickness.

TABLE 7-16. WATER BALANCE FOR WETTING: DEMOLITION OF MODEL PLANTS

Model type	Water applied[a] (gal)	Water absorbed (gal)	Potential runoff (gal)
5-unit apartment	357	237	120
50-unit apartment	10,583	7,046	3,537
Small school	3,355	2,234	1,121
Medium school	18,038	12,009	6,029
Large school	52,817	35,165	17,652
Cargo ship	13,176	8,772	4,404
Cruise ship	--	--	--
Small hospital	195	129	66
Medium hospital	21,457	14,286	7,171
Large hospital	8,719	5,805	2,914
Small hotel	10,875	7,240	3,635
Large hotel	31,538	20,997	10,541
Small office building	616	410	206
Medium office building	5,656	3,766	1,890
Large office building	83,107	55,331	27,776
Department store	130	86	44
Small grocery	65	43	22
Small industrial boiler	713	475	238
Medium industrial boiler	4,651	3,097	1,554
Small refinery	281,474	187,402	94,072
Medium refinery	1,001,026	666,470	334,556
Small power plant	1,151	766	385
Medium power plant	41,699	27,763	13,936
Single-unit dwelling			
Model A	65	43	22
Model B	81	54	27
Model C	195	129	66

[a]At an application rate of 1.5 gal/10 ft^2.

TABLE 7-17. WATER BALANCE FOR WETTING: RENOVATION OF MODEL PLANTS

Model type	Water applied (gal)[a]	Water absorbed (gal)	Potential runoff (gal)
5-unit apartment	202	183	19
50-unit apartment	1,379	1,252	127
Small school	2,377	2,158	219
Medium school	6,109	5,546	563
Large school	13,489	12,247	1,242
Cargo ship	--	--	--
Cruise ship	238	216	22
Small hospital	48	43	5
Medium hospital	166	151	15
Large hospital	357	324	33
Small hotel	285	259	26
Large hotel	464	421	43
Small office building	404	367	37
Medium office building	3,969	3,604	365
Large office building	31,685	28,766	2,919
Department store	48	43	5
Small grocery	48	43	5
Small industrial boiler	440	399	41
Medium industrial boiler	2,805	2,546	259
Small refinery	345	313	32
Medium refinery	345	313	32
Small power plant	12	11	1
Medium power plant	903	820	83
Single-unit dwelling			
Model A	36	32	4
Model B	48	43	5
Model C	59	54	5

[a]At an application rate of 1.1 gal/10 ft^2.

TABLE 7-18. CREWS AND DURATION OF DEMOLITION AND RENOVATION OF MODEL PLANTS

Model type	Demolition: Number of 4-person crews	Demolition: Duration[a] (days)	Renovation: Number of 4-person crews	Renovation: Duration[a] (days)
5-unit apartment	1	3	1	2
50-unit apartment	4	20	4	3
Small school	4	6	4	6
Medium school	4	33	4	15
Large school	4	98	4	34
Cargo ship	4	24	--	--
Cruise ship	--	--	1	2
Small hospital	1	1	1	1
Medium hospital	4	40	1	2
Large hospital	4	16	1	4
Small hotel	4	20	1	3
Large hotel	4	58	1	5
Small office building	1	5	1	5
Medium office building	4	10	4	10
Large office building	8	77	4	80
Department store	1	1	1	1
Small grocery	1	1	1	1
Small industrial boiler	1	5	1	4
Medium industrial boiler	4	9	4	7
Small refinery	20	104	1	3
Medium refinery	40	185	1	3
Small power plant	4	2	1	1
Medium power plant	4	77	1	9
Single-unit dwelling				
Model A	1	1	1	1
Model B	1	1	1	1
Model C	1	1	1	1

[a]Asbestos removal time only; does not include preparation or cleanup time.

TABLE 7-19. NUMBERS OF FILTRATION UNITS AND FILTERS FOR DEMOLITION AND RENOVATION OF MODEL PLANTS

Model type	Demolition		Renovation	
	Filtration units[a]	Filters[b]	Filtration units[a]	Filters[b]
5-unit apartment	0[c]	0	0[c]	0
50-unit apartment	2	2	0	0
Small school	2	2	0	0
Medium school	2	2	2	2
Large school	2	3	2	2
Cargo ship	2	2	--	--
Cruise ship	--	--	0	0
Small hospital	0	0	0	0
Medium hospital	2	2	0	0
Large hospital	2	2	0	0
Small hotel	2	2	0	0
Large hotel	2	2	0	0
Small office building	0	0	0	0
Medium office building	2	2	0	0
Large office building	4	4	2	2
Department store	0	0	0	0
Small grocery	0	0	0	0
Small industrial boiler	0	0	0	0
Medium industrial boiler	2	2	0	0
Small refinery	10	13	0	0
Medium refinery	20	46	0	0
Small power plant	0	0	0	0
Medium power plant	2	2	0	0
Single-unit dwelling				
Model A	0	0	0	0
Model B	0	0	0	0
Model C	0	0	0	0

[a]One filtration unit for every two four-man removal crew.
[b]One day (8 hr) of service assumed for each filter.
[c]A zero indicates a potential runoff volume $\leq$ 500 gal that is filtered in the decontamination shower.

Labor to service the filtration units was assumed to be 0.5 hr/day/filtration unit. A fully loaded hourly labor rate of $22.21 also was assumed.

Labor cost by model plant for this alternative was estimated as follows:

> Duration of removal (days) [from Table 7-18] x 0.5 hr/day/filtration unit x No. units [from Table 7-19] x $22.21/hr = Model plant labor cost ($) .

When the number of filtration units in Table 7-19 is zero, the cost of filtering runoff in the decontamination shower is given by

> Duration of removal (days) [from Table 7-18] x 0.5 hr/day x $22.21/hr = Model plant cost ($) .

Because it is common practice to filter shower water, no costs are attributable to the alternative that requires shower water to be filtered and the contaminated filter to be disposed of as asbestos waste.

7.2.2.14 Requirements for Waste Storage and Transfer. The additional costs of the temporary waste storage and transfer alternatives described in Chapter 5.0 are estimated below. The alternatives under consideration include limitations on length of storage, storage in leak-tight containers, storage in locked areas to prevent public access, display of warning signs around storage area, weekly inspections, and recordkeeping.

Warning signs to be posted at the entrance to the storage area are estimated to cost $12.95 each.[44] It is assumed that one sign would be needed at the entrance to the storage area.

The cost of inspecting the storage area on a weekly basis includes the labor cost of one worker spending 0.25 hr inspecting the condition of the stored waste. Using a labor rate of $22.21/hr, each inspection is estimated to cost $5.55. In estimating the number of inspections required for the model plants, information on removal rates was obtained from a study on the costs of removal for a building containing 42,000 ft^2 of asbestos.[45] It was estimated that in 1 week, about 9,100 ft^2 of asbestos was removed. For purposes of estimating the storage inspection cost for model plants, it is assumed that for each 9,100 ft^2 of asbestos removed, storage time equals or exceeds 1 week and an inspection would be required.

The cost of recordkeeping is estimated using a labor cost of \$14.55/hr* and an estimated time for recordkeeping of 0.16 hr for a cost of \$2.30 per model plant.[46,47] Table 7-20 present costs for the waste storage alternative for each model plant.

7.2.3 Waste Disposal

7.2.3.1. Regulate All Inactive Disposal Sites. Extending inactive disposal site requirements to all disposal sites involves additional costs for final cover and annotating the deed to the property.

7.2.3.1.1 Final cover. Two final cover options are under consideration, a fixed-depth option and a variable-depth option. The fixed-depth option would require a final cover depth of 36 in. Because the vast majority of States already require 24 in. of final cover, the cost attributable to this option would be for the additional 12 in. of cover. The variable-depth option would require the final cover to be 12 in. more than the frost penetration depth and, in no case, less than 24 in. Costs for both final cover options are presented in Subsection 7.2.3.5.

7.2.3.1.2 Annotate deed. This alternative would require the owners/operators of public and private sanitary landfills that become inactive to note on the deed to the property that asbestos-containing waste is deposited on the property and that information on the quantity of waste and its location is on file with the Administrator. In some States, a notation-of-deed form can be used to add this information to a deed; in other States, it may be easier to prepare a new deed than it is to annotate an existing deed. Preparing a notation-of-deed form, where applicable, or a new deed if that is the appropriate course to follow is estimated to cost \$45.[48] To estimate the annual cost of this charge, the average life of a landfill was estimated at 10 years. Several landfills that provided information on their operation reported operating lives of from 3 to 50 years. A period of 10 years is considered conservative.

7.2.3.2 Eliminate No Visible Emissions as an Option and Require Work Practices at Disposal Sites. This alternative would require milling, manufacturing, and fabricating plants that dispose of their asbestos waste

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*An hourly rate for recordkeeping of \$6.55/hr was adjusted to 1990 using Chemical Engineering cost index and adding 27.3 percent for fringe benefits and 60 percent for overhead as follows:

$$\$6.55/\text{hr} \times 354.7/325.3 \times 1.273 \times 1.60 = \$14.55/\text{hr}$$

TABLE 7-20. MODEL PLANT COSTS FOR TEMPORARY WASTE STORAGE

Model type	Amount (ft^2) of asbestos		Number of inspections		Cost of inspections ($)		Total cost ($)	
	Demolition	Renovation	Demolition	Renovation	Demolition	Renovation	Demolition	Renovation
5-unit apartment	8,130	7,500	0	0	--	--	--	--
50-unit apartment	91,310	50,000	10	5	56.00	28.00	71	43
Small school	44,766	43,200	4	4	22.00	22.00	37	37
Medium school	203,302	111,100	22	12	122.00	66.00	137	81
Large school	447,811	245,000	49	27	271.00	149.00	286	164
Cargo ship	70,000	--	7	0	38.00	--	53	--
Cruise ship	--	700	0	0	--	--	--	--
Small hospital	1,814	213	0	0	--	--	--	--
Medium hospital	105,499	629	12	0	66.00	--	81	--
Large hospital	91,550	1,649	10	0	55.00	--	76	--
Small hotel	4,893	2,557	0	0	--	--	--	--
Large hotel	180,590	4,222	20	0	111.00	--	126	--
Small office building	7,688	7,200	0	0	--	--	--	--
Medium office building	37,425	36,000	4	3	22.00	16.00	37	31
Large office building	515,288	288,000	57	32	316.00	177.00	331	192
Department store	1,243	398	0	0	--	--	--	--
Small grocery	323	213	0	0	--	--	--	--
Small industrial boiler	2,814	1,736	0	0	--	--	--	--
Medium industrial boiler	16,335	10,755	1	1	6.00	6.00	21	21
Small refinery	1,001,924	3,142	110	0	610.00	--	625	--
Medium refinery	3,638,491	3,142	400	0	2,220.00	--	2,235	--
Small power plant	4,957	132	0	0	--	--	--	--
Medium power plant	109,748	9,766	12	1	66.00	6.00	81	21
Single-unit dwelling								
Model A	213	72	0	0	--	--	--	--
Model B	325	213	0	0	--	--	--	--
Model C	2,685	1,288	0	0	--	--	--	--

Notes:
Warning sign cost is $12.95 per model plant.
Recordkeeping cost is $2.30 per model plant.
Cost per inspection is $5.55.

on-site to comply with work practices (i.e., either cover waste daily with 6 in. of nonasbestos cover or apply resinous or petroleum-based dust suppressants to the waste surface). The alternative would eliminate no visible emissions as a compliance option.

Amounts of asbestos waste disposed of annually on-site by manufacturers of asbestos products and by representative plants in each product category are given in Table 7-21.[49,50] Asbestos product categories that generate little waste and/or dispose of small amounts on-site are not listed.

Because mills currently employ work practices at their disposal sites, adoption of this alternative would not involve additional costs for mills. However, manufacturers would be confronted with the additional cost of applying 6 in. of daily cover. (Because the waste amounts are so small at most plants, daily disposal is not anticipated. Most plants are expected to store their waste until a suitable volume is reached and then dispose of it.) The cost of spreading the additional cover was derived from an EPA report, which gave a 1975 cost for spreading 6 in. of cover as \$1,064/acre.[51] Adjusted to 1990 with a cost index from Chemical Engineering,[52] the cost of spreading 6 in. of cover over an acre is:

$$\$1{,}064 \times \frac{354.7}{182.4} = \$2{,}069/\text{acre} \quad .$$

The cost per square foot of 6-in. cover is \$2,069/acre x 1 acre/43,560 ft^2 = \$0.048/ft^2.

To estimate costs, it was necessary to estimate a surface area for the landfill. Landfill surface area was estimated by dividing the asbestos waste volume by its depth. Landfill depths were assumed to be 5 ft, except for landfills at A/C sheet and A/C pipe plants where the depth was taken as 10 ft. Short tons of waste were converted to pounds by multiplying by 2,000 $lb\text{-}ton^{-1}$, and to cubic feet by dividing by an assumed density of 60 lb/ft^3. Finally, the annual cost of this alternative was calculated by multiplying the surface area in square feet by \$0.048/ft^2. Annual costs of this alternative for manufacturers are shown in Table 7-22.

7.2.3.3 Cover Waste Before Compaction. Under this alternative, asbestos waste that has been deposited in a landfill would have to be

TABLE 7-21. WASTE DISPOSED OF ON SITE BY MANUFACTURERS, 1981

	Product category					
Waste type	Paper products	A/C sheet	A/C pipe	Friction products	Packings and gaskets	Plastics
Waste from product category (short tons/yr)[a]	21,628	18,470	24,685	19,291	2,103	2,092
Percent of waste disposed of on site[a]	23	48	50	9	35	30
Waste disposed of on site from product category (short tons/yr)[a]	4,919	8,800	12,343	1,762	743	628
Waste generated by representative plant (short tons/yr)[b]	210	5,339	6,261	3,446	1,066	104
Waste disposed of on site by representative plant (short tons/yr)	48	2,563	3,131	310	373	31

[a]Adapted from Krusell, N., Cogley, D. and Flynn, G., Aggregate Statistics from the Toxic Substances Control Act Asbestos Reporting Rule, Final Report, Contract No. 68-01-5960, Technical Directive No. 24. Bedford, MA: GCA Corporation, January 1984.

[b]From Table 7-2 of Emission Standards and Engineering Division, U.S. Environmental Protection Agency. National Emission Standards for Asbestos--Background Information for Proposed Standards. Draft. Research Triangle Park, NC. July 15, 1986.

TABLE 7-22. ANNUAL COSTS FOR 6 IN. OF DAILY COVER AT DISPOSAL SITES OPERATED BY REPRESENTATIVE PRIMARY PROCESSORS

Category	On-site disposal (short ton/yr)	Cost ($/yr)
Paper products	48	15
A/C sheet	2,563	410
A/C pipe	3,131	501
Friction products	310	99
Packings and gaskets	373	119
Plastics	31	10

covered with a minimum of 3 in. of nonasbestos material before it could be leveled or compacted. The additional cost for covering the waste was derived from an EPA report, which gave the 1975 cost of covering one acre with 6 in. of dirt as the cost of operating a bulldozer $840/acre) and labor ($224/acre = 28 hr to cover 1 acre x $8/hr labor) for a total of $1,064/acre.[53] The cost of spreading 3 in. (or one-half the amount) would be $532/acre. Adjusted to the first quarter of 1990 using the Chemical Engineering overall cost index, the cost of spreading 3 in. of cover over an acre is:

$$\$532 \times 354.7/182.4 = \$1{,}035/\text{acre} \quad .$$

The cost per square foot of 3-in. cover is:

$$\$1{,}035/\text{acre} \times 1\ \text{acre}/43{,}560\ \text{ft}^2 = \$0.024/\text{ft}^2 \quad .$$

It is necessary to know the area occupied by the waste in order to estimate the costs. The area was estimated by dividing the volume of the waste deposit by its depth. The depth of waste was estimated at 5 ft. The annual costs of placing a 3-in. cover over asbestos waste was estimated as follows for the small and large model landfills:

- For the small, privately owned landfill model:
  $(15\ \text{yd}^3\ \text{asbestos/wk} \times 27\ \text{ft}^3/\text{yd}^3)/5\ \text{ft} \times 52\ \text{wk/yr} \times \$0.024/\text{ft}^2 =$
  $101/yr
- For the large, publicly owned landfill model:
  $(152\ \text{yd}^3\ \text{asbestos/wk} \times 27\ \text{ft}^3/\text{yd}^3)/5\ \text{ft} \times 52\ \text{wk/yr} \times \$0.024/\text{ft}^2 =$
  $1,024/yr.

Covering asbestos waste before compacting it is commonly practiced by landfills. It is estimated that only about 20 percent of asbestos waste is not currently covered before it is compacted. If no additional waste is placed on top of the 3-in. cover, the costs of applying a cover before leveling and compaction can be included in the costs of daily cover.

7.2.3.4 <u>Require Intermediate Cover</u>

7.2.3.4.1 <u>No intermediate cover</u>. There are no costs for this option.

7.2.3.4.2 <u>Intermediate cover</u>. An additional cost would result from adding the additional 6 in. of cover to the 6 in. of daily cover already in place.

The cost of spreading the additional cover was derived from an EPA report, which gave a 1975 cost for spreading 6 in. of cover as $1,064/acre

($840/acre for equipment operation plus $224 labor).[54] Adjusted to 1990 with a cost index from Chemical Engineering,[55] the cost of spreading 6 in. of cover over an acre is:

$$\$1{,}064 \times 354.7/182.4 = \$2{,}069/\text{acre} \quad .$$

The cost per square foot of 6-in. cover is $2,069/acre x 1 acre/43,560 ft^2 = $0.048/$ft^2$.

To estimate costs, it was necessary to know the area in the landfill occupied by the asbestos waste. The area occupied by the asbestos waste was estimated by dividing the volume of the asbestos waste deposit by its depth. Actual landfill depths ranged from less than 8 ft up to 30 ft, with an average of about 10 ft.[56] Thus, the annual costs of placing an intermediate cover on sites designated for asbestos were obtained by dividing the annual volume of waste by 10 ft and multiplying by $0.048/$ft^2$ as follows:

- For the small, privately owned landfill model:

  [(15 yd^3 asbestos/wk x 27 ft^3/yd^3)/10 ft] x 52 wk/yr x $0.048/$ft^2$ = $101/yr

- For the large, publicly owned landfill model:

  [(152 yd^3 asbestos/wk x 27 ft^3/yd^3)/10 ft] x 52 wk/yr x $0.048/$ft^2$ = $1,024/yr.

An additional cost would result from adding the additional 12 in. of cover to the 6 in. of daily cover already in place. The cost per square foot for 12 in. of cover is 2 x $0.048/$ft^2$ = $0.096/$ft^3$, and the costs for this option are as follows:

- For the small, privately owned landfill model:

  [(15 yd^3 asbestos/wk x 27 ft^3/yd^3)/10 ft] x 52 wk/yr x $0.096/$ft^2$ = $202/yr

- For the large, publicly owned landfill model:

  [(152 yd^3 asbestos/wk x 27 ft^3/yd^3)/10 ft] x 52 wk/yr x $0.096/$ft^2$ = $2,049.

The costs of intermediate cover can be included in the costs of applying a final cover. However, if intermediate cover costs are reported separately, final cover costs should be reduced by a like amount.

7.2.3.5 Require Increased Final Cover.

7.2.3.5.1 Fixed-depth option. Because most of the States already require a minimum of 24 in. of final cover, an additional cost would result only from applying the extra 12 in. of cover to obtain a final cover of 36 in. The cost of spreading the additional cover was derived from an EPA report, which gave a 1975 cost for spreading 6 in. of cover as $1,064 acre ($840 for equipment operation plus $224 labor).[57] Adjusted to 1990 with a cost index from Chemical Engineering,[58] the cost of spreading 6 in. of cover over an acre is:

$$\$1,064 \times 354.7/182.4 = \$2,069/\text{acre} \quad .$$

The cost per square foot of 6-in. cover is $\$2,069/\text{acre} \times 1\ \text{acre}/43,560\ \text{ft}^2 = \$0.048/\text{ft}^2$, and the corresponding cost for 12 in. of cover is $2 \times \$0.048/\text{ft}^2 = \$0.096/\text{ft}^3$.

To estimate costs, it was necessary to know the area in the landfill to be occupied by the asbestos waste. The area occupied by asbestos waste was estimated by dividing the volume of the asbestos waste deposit by its depth. Actual landfill depths ranged from less than 8 ft up to 30 ft, with an average of about 10 ft.[59] Thus, the annual costs of putting a final cover on sites designated for asbestos were obtained by dividing the annual volume of waste by 10 ft and multiplying by $\$0.096/\text{ft}^2$ as follows:

- For the small, privately owned landfill model:

  $[(15\ \text{yd}^3\ \text{asbestos/wk} \times 27\text{ft}^3/\text{yd}^3)/10\ \text{ft}] \times 52\ \text{wk/yr} \times \$0.096/\text{ft}^2 = \$202/\text{yr}$

- For the large, publicly owned landfill model:

  $[(152\ \text{yd}^3\ \text{asbestos/wk} \times 27\ \text{ft}^3/\text{yd}^3)/10\ \text{ft}] \times 52\ \text{wk/yr} \times \$0.096/\text{ft}^2 = \$2,049/\text{yr}$.

7.2.3.5.2 Variable-depth option. Annual costs for the landfill model described in Subsection 5.1.5 and for several final cover depths are given in Table 7-23. Costs were calculated as described above. The final cover depths shown in the table bracket the range that might be required to prevent frost penetration into asbestos-bearing layers in landfills in various locations in the United States. The freezing degree-days shown in

TABLE 7-23. ANNUAL COSTS FOR VARIABLE-DEPTH FINAL COVER OPTION

Depth (in.)	Freezing degree-days[a]	Annual cost ($) Small, privately owned landfill	Annual cost ($) Large, publicly owned landfill
24	884	-0-	-0-
30	1,266	101	1,025
36	1,717	202	2,049
42	2,237	303	3,074
48	2,825	404	4,098
54	3,482	505	5,122
60	4,207	606	6,146

[a]Calculated from $Y = -6.46228 + 1.02471 \sqrt{X}$ where Y is frost depth in inches and X is accumulated freezing degree-days (°F) for the season.[60]

Table 7-23 are values that an engineer might use to design a final cover. For example, in parts of northern Minnesota next to the Canadian border, the design value would approach 4,000 degree-days, and a final cover depth in the vicinity of 54 to 60 in. would be necessary.[61]

7.2.3.6 Require Covers or Enclosures on Waste Transport Vehicles. The cost of requiring transportation in a vehicle with an enclosed or covered cargo area is small. Given the alternative of a onetime purchase of a canvas tarp if the contractor has only open vehicles or the recurring rental cost of a vehicle with an an enclosed cargo area (e.g., a Ryder or U-Haul), EPA assumes that the lowest cost method of compliance (purchase of the reusable canvas tarp) would be favored. An 18-oz waterproof canvas tarp, 15 by 20 ft to cover a medium-sized vehicle carrying a typical load (20 yd^3), costs $127. The service life of the tarp is estimated at 4 years for loads of rough, pointed objects (e.g., construction debris) and up to 10 years for containerized loads, for an overall average of 6 to 7 years.[62] Approximately 85 percent of transport vehicles with covered loads use this weight of a waterproof tarp. However, 27 percent of the States already require the use of a vehicle with an enclosed cargo area or a vehicle cover, and contractors in these States would not be impacted by this potential requirement. Fourteen (14) of 50 States and the District of Columbia currently require vehicles carrying asbestos waste from school or nonschool abatement projects to be enclosed or covered. These States are Alaska, Arkansas, California, Illinois, Kansas, Maryland, Massachusetts, Nebraska, New Mexico, New York, North Carolina, Oklahoma, Pennsylvania, and Virginia. Four of these States require asbestos waste to be transported in an enclosed cargo area; one State requires openings to be securely closed; one State requires tightly enclosed vehicles; and one State prohibits transportation in an open vehicle. Two States require asbestos waste to be transported in an enclosed cargo area or that the vehicle be equipped with a canvas cover. Two States require that asbestos waste be transported in an enclosed cargo area or the the cargo area be completely enclosed with 6-mil plastic sheeting and that the vehicles be decontaminated at the disposal site. One State specifically requires a vehicle cover, and two States require the vehicle to be adequately enclosed or that the asbestos waste be in sealed drums or locked containers.[63]

At the Federal Level, regulations implementing AHERA (Appendix D to 40 CFR 763, Subpart E) require local education agencies to provide for the transportation of asbestos waste in accordance with EPA's asbestos waste guidance document (EPA/530-SW-85-007, May 1985), parts of which are reprinted in Appendix D to the rule.[64] Appendix D states that additional precautions should be taken in waste transport (and disposal) due to the potential hazards and subsequent liabilities associated with exposure. In accordance with recommendations in the guidance document, the rule requires transport vehicles used in school abatement projects to have an enclosed carrying compartment or use a canvas cover sufficient to contain the waste, prevent damage to containers, and prevent fiber release. Roll-off boxes also must be covered. Thus, the potential revision to the current NESHAP already is in place for abatements performed in schools. In addition to the State and AHERA regulations requiring covered or enclosed vehicles, contractors are selecting enclosed vehicles to transport waste because they can also be used for waste storage during the removal operation at the removal site and can be locked to prevent unauthorized access. Many specifications written for removals include requirements for covered or enclosed transport vehicles.[65]

7.2.3.7. Require Decontamination of Waste Hauling Vehicles. Under this revision, vehicles must be lined with polyethylene sheeting, and any asbestos contamination must be cleaned up by either vacuuming with a HEPA-filtered vacuum or wiped up with amended water.

It is assumed that trucks would be lined with 6-mil polyethylene: The floors would be double-lined, and walls and ceilings would be single-lined. Polyethylene sheeting cost about $0.04/ft^2; for a truck with a 20-yd^3 capacity, which would require about 500 ft^2 of polyethylene, the cost would be $20. It is estimated that two workers working for 30 min would be required to install the lining. At $22.21/hr per worker, the total cost of lining the truck would be $42.

It is assumed that workers would remove the lining after unloading the waste and discard it at the landfill as ACM waste. Any visible contamination of the truck would be wiped up with amended water, placed in a bag, and disposed of along with the rest of the asbestos waste. The truck would be further cleaned using a HEPA-filtered vacuum upon arrival back at the asbestos abatement site. If the waste-hauling vehicle has completed the final disposal and will not return to the asbestos abatement site, the truck will be HEPA-filter vacuumed at the landfill or the contractor's place of business. In the case that the waste-hauling vehicle is rented, the vehicle would be decontaminated before being returned to the rental agency. It is estimated that it will require two workers an hour to remove and dispose of the lining, wipe up any visible contamination, and vacuum the truck. The labor cost of these activities would be $44.42. The contractor would already have a HEPA-filtered vacuum, so there would be no additional cost associated with vacuuming the truck. If the truck is to be used to transport another load, it would be relined with polyethylene sheeting. Therefore, the total unit cost per load is $86 ($42 for lining the truck and $44 for taking down the lining and cleaning the truck).

Table 7-24 presents the estimated cost of requiring vehicle decontamination for each of the model plants. For each model, the waste generated, the number of wasteloads requiring lining and decontamination (assuming 20 yds for a typical load), and the total cost are included.

7.2.3.8 Regulate Import/Export of Asbestos Waste. Cost estimates have not been made pending specification of regulatory alternatives.

7.2.4 Spraying and Insulation

7.2.4.1 Ban Spraying. This option would extend the prohibition against the spray application of materials containing more than 1 percent asbestos (except those encapsulated in resinous or bituminous binder) to prohibit the spraying of equipment and machinery. The current NESHAP prohibits the use of materials that contain greater than 1 percent asbestos only for spray-on application on buildings, structures, pipes, and conducts unless the asbestos fibers in the materials are encapsulated with a bituminous or resinous binder during spraying and the materials are not friable after drying. With the exception of bituminous and resinous materials, spray-on materials containing more than 1 percent asbestos are no longer manufactured. Whereas it was formerly necessary to exempt asbestos materials used on machinery, the development of nonasbestos substitutes has eliminated that need. As a result, no additional costs would be incurred under this alternative.

TABLE 7-24. VEHICLE DECONTAMINATION COST ESTIMATES

Model type	Amount of waste generated (yd^3)		Number of loads		Cost ($)	
	Demolition	Renovation	Demolition	Renovation	Demolition	Renovation
5-unit apartment	22	17	1	1	86	86
50-unit apartment	653	116	33	6	2,838	516
Small school	207	200	10	10	860	860
Medium school	1,457	514	73	26	6,278	2,236
Large school	3,259	1,135	163	57	14,018	4,902
Cargo ship	813	--	41	--	3,526	--
Cruise ship	--	20	--	1	--	86
Small hospital	12	4	1	1	86	86
Medium hospital	1,324	14	66	1	5,676	86
Large hospital	538	30	27	2	2,322	172
Small hotel	671	24	34	1	2,924	86
Large hotel	1,946	39	97	2	8,342	172
Small office building	38	34	2	3	172	172
Medium office building	349	334	17	17	1,462	1,462
Large office building	5,128	2,666	256	133	22,016	11,438
Department store	8	4	1	1	86	86
Small grocery	4	4	1	1	86	86
Small industrial boiler	44	37	2	2	172	172
Medium industrial boiler	287	236	14	12	1,204	1,032
Small refinery	17,368	29	868	1	74,648	86
Medium refinery	61,767	29	3,088	1	265,568	86
Small power plant	71	1	4	1	344	86
Medium power plant	2,573	76	129	4	11,094	344
Single-unit dwelling						
Model A	4	3	1	1	86	86
Model B	5	4	1	1	86	86
Model C	12	5	1	1	86	86

Notes: A typical wasteload is 20 yd^3.
The cost of lining the vehicle is $42/load.
The cost of taking down the lining and cleaning is $44/load.

7.2.4.2 Prohibit Use of Insulating Materials Containing More Than 1 Percent Asbestos. Insulation material manufactured with mineral ingredients, such as vermiculite, may contain trace amounts of asbestos even though asbestos is not added as an ingredient. For example, some vermiculite loose-fill insulation installed in older buildings may contain tremolite, a form of asbestos. An estimated 476,000 tons of loose-fill vermiculite were installed in this country from 1971 to 1980. However, asbestos may or may not be present in the vermiculite; a major factor appears to be where the vermiculite was mined. Canadian studies conducted to date indicate that vermiculite mined in South Africa is virtually asbestos-free.[66]

OSHA currently requires that any construction product that contains more than 0.1 percent asbestos must be labeled. A materials safety data sheet apprises workers of the contents of the product and advises them on precautionary measures. In addition, OSHA currently is conducting a rulemaking to determine if nonasbestiform tremolite, anthophyllite, and actinolite should be regulated in the same way as asbestos tremolite, anthophyllite, and actinolite.[67]

Five States currently have regulations affecting the use of asbestos-containing insulation products. These States are Hawaii, Massachusetts, New York, Rhode Island, and South Carolina. Massachusetts prohibits the installation or reinstallation of any ACM. New York, Rhode Island, and South Carolina require that damaged areas of fireproofing or thermal insulation be repaired using a nonasbestos material. Hawaii requires that employees engaged in the removal or demolition of asbestos insulation or coverings be provided with respiratory equipment and special clothing.[68]

The Toxic Substances Control Act (TSCA) ban and phaseout rule for asbestos will prohibit the manufacture and distribution of many types of asbestos products in the coming years.[69] Although asbestos pipeline wrap and roofing felt are covered by the rule, thermal pipe, boiler, and other insulation products are not covered; however, the 1978 NESHAP revision effectively prohibited the use of commercial asbestos in the manufacture of these products.

Although commercial asbestos is no longer added as an ingredient in insulation materials that are either molded and friable or wet-applied and friable after drying, asbestos can be present as a contaminant. This revision would limit the amount of asbestos in these products to no more than 1 percent, whether commercial or contaminant. Similar rules are already in place in four States: Massachusetts, New York, Rhode Island, and South Carolina. In these States, nonasbestos insulation must be used wherever practicable in new installations and repair jobs. "Nonasbestos" means the material cannot contain more than 1 percent asbestos by weight, of any type. This NESHAP revision would limit the installation of ACM that could otherwise require removal in the future. As discussed below, little or no impact would occur as a result of this revision. Major manufacturers of insulating material have stated that their products currently contain much less than 1 percent asbestos (whether commercial or contaminant); others import vermiculite from mines believed to be free of asbestos-contaminated ores. Except for the trace amounts, tremolite is removed in the processing of vermiculite to levels considered not detectable by polarized light microscopy analytical methods.[70,71]

The EPA considers that limiting the commercial or contaminant asbestos content of insulating material to no more than 1 percent will have little or no impact on the vast majority of manufacturers because product liability concerns and availability of substitutes have led to products that are free of commercial or contaminant asbestos. The EPA has not identified any insulating materials currently being used that contain more than 1 percent asbestos. However, the revision could affect any remaining manufacturers that have not already reduced contaminant asbestos concentrations to less than 1 percent.

7.2.5 Roadways

7.2.5.1 Control Removal and Recycling of Asbestos Pavement. Potential costs for controlling the removal of pavement would be for dust suppression at the removal site. No additional cost would be required because the removal process makes use of wet sawing that keeps dust from forming. Because the asbestos is encapsulated in asphalt, the large chunks of paving that are transported and disposed of in a landfill would not require control.

Dust generated from recycling operations would be controlled by existing baghouses at the asphalt batching plants handling the broken paving. No further control, and therefore no further costs, would be required.

To locate asbestos-containing pavement, pavement would have to be sampled and tested. Low-temperature ashing and examination under an optical microscope would cost about $100 per sample. Sampling and sample transport would add to the cost although core samples that are now routinely taken may be usable for determining asbestos content.[72]

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APPENDIX C

ASBESTOS EMISSION ESTIMATES FOR MILLING, MANUFACTURING, FABRICATING, DEMOLITION, RENOVATION, AND WASTE DISPOSAL

APPENDIX C

ASBESTOS EMISSION ESTIMATES FOR MILLING, MANUFACTURING, FABRICATING, DEMOLITION, RENOVATION, AND WASTE DISPOSAL

C.1 INTRODUCTION

Emission estimates were made for sources of asbestos emissions including asbestos milling, manufacturing, and fabricating and demolition and renovation activities. Emissions from the disposal of asbestos-containing waste from these sources were also estimated. Few emissions measurement data exist for these sources and engineering techniques were used to estimate emissions. The methods used to estimate emissions were sent for review to representatives of the various affected industries, to environmental groups, and to experts on fugitive emissions. Their comments were incorporated as appropriate.

C.2 MILLING, MANUFACTURING, AND FABRICATING PROCESS EMISSIONS

Because few measurement data exist for asbestos emission sources, emissions were estimated using the following engineering approach. Estimates of asbestos emissions in the absence of any controls (uncontrolled) were made first as a basis for calculating controlled emissions. Inlet grain loadings for control devices were also calculated to help characterize sources and control device efficiencies. Emissions from control devices under the current National Emission Standards for Hazardous Air Pollutants (NESHAP) were estimated taking into account both the normal operating efficiencies and the failure mode efficiencies of control devices. Nearly all of the control devices used by the asbestos industry for controlling asbestos emissions are baghouses; a relatively small number of scrubbers are also used. Finally, emissions estimates were made for the sole control technology regulatory alternative being considered (other than those in place under the current NESHAP), which would require that all asbestos-containing exhaust streams be filtered by high-efficiency particulate air (HEPA) filters following a baghouse or other primary collector. The methods used to estimate emissions and the results are described in detail in the following sections.

C.2.1 Uncontrolled Emissions

To estimate emissions for each level of regulatory control, uncontrolled emissions were estimated for milling, manufacturing, and fabricating sources. Although not actually occurring, they are estimates of what emissions would be in the absence of controls. Uncontrolled emission estimates were made from 1981 confidential business data submitted by 291 mills and manufacturing sources and 62 fabricators to EPA's Office of Pesticides and Toxic Substances (OPTS) under the authority of Section 8(a) of the Toxic Substances Control Act (TSCA). Emissions were estimated for individual sources and then aggregated by source category to protect confidentiality. The aggregated numbers were then adjusted for the decrease in asbestos production since 1981. OPTS reviewed the estimates before adjustment and determined that no confidential information is revealed. Uncontrolled asbestos emissions were estimated for individual sources using the following reported information:

- Material collected annually in control devices, primarily baghouses (pounds)
- Asbestos content of material collected in control device (percent)
- Control device efficiency for particulate matter (percent).

Uncontrolled emissions were assumed to equal total control device inlet loadings. Asbestos emissions were calculated as follows:

$$\text{Uncontrolled Asbestos Emissions (kg/yr)} = \frac{\text{Control device waste x asbestos content of waste}}{\text{Control device efficiency}} .$$

Where individual plants did not supply all of the above information, average values for the source category were used. The individual plant emission estimates were then aggregated by source category and are presented in Table C-1.

It should be noted that control device efficiencies supplied by individual plants and used in the calculation of uncontrolled emissions

TABLE C-1. UNCONTROLLED NATIONWIDE ASBESTOS EMISSIONS[a] FROM MILLING, MANUFACTURING, AND FABRICATING, 1989

Source category	Uncontrolled emissions (kg/yr)
Milling	2,350,000
Manufacturing	
Friction	2,630,000
A/C pipe	257,000
A/C sheet	217,000
Paper	24,000
Coatings, sealants	31,000
Plastics	162,000
Textiles	19,000
Packings, gaskets	12,000
Other	14,000
V/A tile	25,000
Chlorine	--[b]
Subtotal	3,391,000
Fabricating	304,000
Total[c]	6,045,000

[a]Emissions from the asbestos industry are controlled. Uncontrolled emissions are hypothetical and used for making estimates of controlled emissions.

[b]No data for an estimate.

[c]Column total may not agree due to round-off error.

were either vendor-supplied estimates or estimates based on knowledge of typical baghouse and scrubber performance. No emissions measurement data for particulate matter or asbestos were supplied as the basis for reported efficiencies. The use of the reported efficiency introduces some uncertainty into the estimates of uncontrolled emissions. However, no attempt was made to re-estimate the reported values based upon the limited test data on baghouse efficiencies because the uncontrolled emission estimates are relatively insensitive to control device efficiency within the range of average efficiencies reported (94.45-99.98 percent). With the exception of one category, average reported efficiencies were all greater than 98 percent. The result is that the quantity of material collected in the control device and its asbestos content, and not control device efficiency, are primarily responsible for determining the magnitude of uncontrolled emissions.

C.2.2 Inlet Particulate Grain Loading

Total particulate inlet grain loadings were calculated for each source category and are averages weighted by gas volume and hours of operation. Inlet loading is used to help determine the control device efficiencies and characterize the sources as high or low inlet loading sources. This information is used later in calculating emissions under the current NESHAP.

Using confidential business information supplied to the U.S. Environmental Protection Agency (EPA) by asbestos mills, manufacturers, and fabricators, inlet grain loadings were calculated for individual control devices as follows:

$$\text{Total particulate inlet grain loading } (\text{gr/ft}^3) = \frac{W \times 7{,}000 \text{ gr/lb}}{E/100 \times Q \times t \times 60 \text{ min/hr}}$$

where

W = total waste collected in device (lb/yr)
E = reported control device efficiency (%)
Q = gas volume (ft^3/min)
t = operating schedule (hr/yr).

Inlet loadings for individual control devices were compiled and averaged by source category. Plants that did not report all of the above information for each control device were excluded from this calculation. Complete information was available for about 200 plants and about 500 control devices. Average total grain loadings are presented in Table C-2.

C.2.3 Emissions Under the Current NESHAP

The fabric filter (baghouse) is the principal device used to control atmospheric emissions in asbestos milling, manufacturing, and fabricating industries. While testing has shown that baghouses achieve very high (99.99 percent) overall removal efficiencies during normal operation,[1] failures resulting in visible emissions do occasionally occur in segments of the asbestos industry. In particular, visible emissions have been reported from mills and A/C pipe and friction products plants.[2] Weighted average inlet concentrations from these sources range from 1.0 gr/ft^3 for A/C pipe plants to 2.86 gr/ft^3 for mills.

C.2.3.1 Baghouse Failure Model. The baghouse failure model summarized in Table C-3 was developed to quantify the emissions resulting from baghouse failures. The model is based on a 5,000-acfm baghouse, with a pressure drop of 4 in. H_2O, which is the maximum allowed by the current regulation, and a hole the size of a half dollar (about 1-1/3 in.) in a single bag.[3] The hole is assumed to occur suddenly as a result of abrasion.

For a normal operating mode efficiency of 99.99% and an inlet concentration of 1.0 gr/ft^3, which is a typical high inlet loading for the asbestos industry, the outlet concentration during failure is calculated as follows:

Velocity of gas through hole

$$v = \sqrt{\rho / p}$$

where

ρ = pressure drop (lb_f/ft^2)

p = density of air ($slugs^*/ft^3$)

$$v = \sqrt{\frac{20.82 \ lb_f/ft^2}{0.00234 \ \frac{lb_f s^2/ft}{ft^3}}}$$

$$v = \sqrt{8{,}897 \ \frac{ft^2}{s^2}}$$

$$= 94.3 \text{ ft/s or } 5{,}660 \text{ ft/min.}$$

TABLE C-2. INLINE GRAIN LOADING[a]

Source category	Weighted average inlet loading (gr/ft^3)
Mills	2.86
Manufacturing	
Friction	1.04
A/C pipe	1.00
A/C sheet	1.83
Paper	.07
Coatings, sealants	.05
Plastics	.88
Textiles	.03
Packings, gaskets	.002
V/A tile	.45
Insulation	.005
Fabrication	.18

[a]Total particulate.

TABLE C-3. BAGHOUSE FAILURE MODEL

	Inlet concentration (gr/ft^3) 1.0	Inlet concentration (gr/ft^3) 0.03
Normal operating mode efficiency	99.99%	99.99%
Gas flow	5,000 acfm	5,000 acfm
Cloth area	2,500 ft^2	2,500 ft^2
Pressure drop at failure	4 in H_2O	4 in H_2O
Failure: diameter of hole in a single bag	1 1/3 in.	1 1/3 in.
Outlet concentration during failure	0.011 gr/ft^3	0.0003 gr/ft^3
Failure mode efficiency	98.90%	98.90%
Change in efficiency	1.09%	1.09%

Quantity of gas through hole

$Q = av = \pi r^2 v$

where

a = area of hole (ft^2)
r = radius of hole (ft)
v = gas velocity (ft/min)

$$Q = 3.1416 \left(\frac{1.33 \text{ in}/2}{12 \text{ in/ft}}\right)^2 \quad 5{,}660 \text{ ft/min}$$

$= 54.6 \text{ ft}^3\text{/min.}$

Mass of dust through hole

Mass (gr/min) = gas through hole (ft^3/min) x inlet concentration (gr/ft^3)

= 54.6 ft^3/min x 1.0 gr/ft^3

= 54.6 gr/min.

Mass of dust through fabric

Mass (gr/min) = gas through fabric (ft^3/min) x outlet concentration (gr/ft^3)

= (5,000 - 54.6) ft^3/min x 0.0001 gr/ft^3

= 0.4945 gr/min.

Total mass of dust to atmosphere

Total mass (gr/min) = mass through hole + mass through fabric

= 54.6 gr/min + 0.4945 gr/min

= 55.09 gr/min.

---

*1 slug = $\frac{1 lb_f s^2}{ft}$.

Failure mode outlet concentration

$$\text{Outlet concentration (gr/ft}^3\text{)} = \frac{\text{total mass to atmosphere (gr/min)}}{\text{gas flow (ft}^3\text{/min)}}$$

$$= 55.09 \text{ gr/min} \quad 5{,}000 \text{ ft}^3\text{/min}$$

$$= 0.011 \text{ gr/ft}^3.$$

Failure mode efficiency, n, is given by:

$$n = \frac{\text{Inlet concentration (gr/ft}^3\text{)} - \text{Outlet concentration (gr/ft}^3\text{)}}{\text{Inlet concentration (gr/ft}^3\text{)}} \times 100$$

$$\frac{1.0 \text{ gr/ft}^3 - 0.011 \text{ gr/ft}^3}{1.0 \text{ gr/ft}^3} \times 100$$

$$= \quad 98.90\%.$$

The absolute change in efficiency of 1.09 percent is a constant for this baghouse failure model and is independent of inlet dust concentration, as shown in Table C-3. The 0.03-gr/ft^3 inlet loading was selected as a representative low concentration for the asbestos industry.

C.2.3.2 Detection of Failures. Based on experience with emissions from coal-fired boilers, the Office of Research and Development (ORD) estimates that asbestos emissions from a 2-ft diameter stack, which is typical of the asbestos industry, would probably be visible at outlet concentrations ranging from 0.008 to 0.7 gr/ft^3.[4] As shown above, the baghouse failure model predicts an outlet concentration of 0.011 gr/ft^3, which falls within the estimated range for visible emission monitoring. Because emissions are observed at asbestos baghouses operating with low calculated outlet loadings, failures resulting in outlet concentrations $\geq$0.011 gr/ft^3 are assumed to be visible and detected by visible emission monitoring. Failures producing outlet concentrations <0.011 gr/ft^3 are assumed to be detected during weekly baghouse inspections.

Relevant parameters required for the emission calculations are summarized in Table C-4. Failures at mills and asbestos/cement (A/C) pipe, A/C sheet, and friction products plants are detected by daily visible emission monitoring. Failures at other source categories are detected by

TABLE C-4. EMISSIONS SCENARIO

Baghouse efficiency (%)	
Normal mode	99.99
Failure mode	98.90
Failure frequency (per 1000 operating hours)	
Inlet concentration >0.1 gr/ft^3	0.5
Inlet concentration <0.1 gr/ft^3	0.17
Duration of failure (hr)	
VE monitoring	
1 shift	4
2 shifts	8
Weekly inspections	
1 shift	20
2 shifts	40

TABLE C-5. NATIONWIDE ASBESTOS EMISSIONS (kg/yr) FROM MILLING, MANUFACTURING, AND FABRICATING, 1989

Source category	Current NESHAP	HEPA filter
Milling	329	0.96
Manufacturing		
Friction	494	0.151
A/C pipe	36	0.011
A/C sheet	26	0.008
Paper	8	0.003
Coatings, sealants	17	0.006
Plastics	34	0.010
Textiles	3	0.001
Packings, gaskets	1	0.001
V/A tile	8	0.003
Fabricating	63	0.014
Total	1,019	0.30

TABLE C-6. REDUCTION IN ASBESTOS EMISSIONS FROM REPLACING EXISTING SCRUBBERS WITH IMPROVED UNITS[a]

Waste collected lb/yr, 1981	Percent asbestos	Asbestos collected lb/yr, 1981	Asbestos reduction lb/yr, 1981
6,418	20.	1,283.6	128.36
5	0.08	0.004	0.0004
5,300	0.5	26.5	2.65
7,000	0.5	35.0	3.5
3,500	0.5	17.5	1.75
9,000	8.7	783.	78.3
62,000	25.	15,500.	1,550.
4,747	50.	2,373.5	237.35
2,541	50.	1,270.5	127.05
3,628	0.039	1.41	0.14
			2,129.1

[a]2,129.1 lb/yr = 965.74 kg/yr.
Ratio of 1989 to 1981 production = 0.1377.
965.74 kg/yr x 0.1377 = 133 kg/yr.

Total asbestos escaping to the atmosphere (kg) $= (5 \times 10^{-7}\ kg/m^3)(2{,}250\ ft^3/hr)(.0283\ m^3/ft^3)(8\ hr)$

$= 2.6 \times 10^{-4}\ kg$.

Dividing the total asbestos escaping to the atmosphere by the volume of asbestos material removed gives an emission factor for the dry removal of asbestos. A representative thickness of asbestos is 0.5 in.

$$\text{Emission factor} = \frac{2.6 \times 10^{-4}\ kg}{(225\ ft^2)\ (.5\ in.)\ (.083\ ft/in.)\ (.0283\ m^3/ft^3)}$$

$$= 9.5 \times 10^{-4}\ kg/m^3 \text{ of in-place material.}$$

Wetting is the principal method of reducing emissions under the current NESHAP. Amended water (water plus a wetting agent) is not required by the NESHAP although it is being considered. To estimate emissions under the current NESHAP requirements, an emission factor for wetting with plain, unamended water was used. Wetting with unamended water reduces work place concentrations by about 72 percent from dry removal concentrations[19] ($15 \times 10^6\ f/m^3$) to about $4.2 \times 10^6/m^3$. Assuming all other factors are constant, the emission factor for wet removal is 72 percent less than the dry removal emission factor, or $2.7 \times 10^{-4}\ kg/m^3$ of in-place material.

The emission factor for wet removal using amended water is 90 percent less than the dry removal emission factor, or $9.5 \times 10^{-5}\ kg/m^3$ of in-place material.

Another regulatory alternative being considered would require that during all asbestos removal operations, the work area be kept under negative pressure and all of the air exhausted from the work area filtered by a HEPA filter. To estimate emissions for this alternative, emission factors were developed for the use of negative pressure and HEPA filter systems in conjunction with dry and wet removals. The efficiency of the negative air units was taken as 99.207 percent. The penetration at this efficiency is 0.0079, which is multiplied by the dry and wet emission factors to arrive at the new emission factors. Emission factors were calculated as follows:

Emission factor, dry removal plus HEPA filter (kg/m^3) $= $ dry removal emission factor x 0.0079
$= 9.5\ (10^{-4})\ kg/m^3 \times 0.0079$
$= 7.5 \times 10^{-6}\ kg/m^3$

Emission factor, wet removal plus HEPA filter (kg/m^3) $=$ wet removal emission factor x 0.0079
$= 2.7\ (10^{-4})\ kg/m^3 \times 0.0079$
$= 2.1 \times 10^{-6}\ kg/m^3$

Emission factor, wet removal with amended water plus HEPA filter (kg/m^3) $=$ wet removal (amended water) factor x 0.0079
$= 9.5\ (10^{-5})\ kg/m^3 \times 0.0079$
$= 7.5\ (10^{-7})\ kg/m^3$.

C.3.2 Nationwide Emissions

C.3.2.1 With Current Threshold. Annual nationwide emissions were calculated by multiplying the amount of asbestos material removed annually by the appropriate emission factors. The quantity of asbestos removed annually is based on representative models of asbestos-containing buildings (see Chapter 5) and estimates of the average number of demolitions and renovations occurring annually. The average amounts of asbestos material removed annually are estimated to be 159,000 to 189,000 m^3 for demolitions and 1,570,000 to 1,866,000 m^3 for renovations. For subsequent calculations averages of these ranges are used, i.e., 174,000 m^3 for demolitions and 1,718,000 m^3 for renovations.

C.3.2.1.1 NESHAP emissions. Emissions under the current NESHAP were estimated for two situations: the first assumes all removals are done in full compliance with the NESHAP and the second assumes that, based on enforcement experience, there is currently less than full compliance with the NESHAP. Furthermore, it is estimated that as a result of freezing weather and the potential for equipment damage due to wetting, 85 percent of demolitions performed in compliance with the NESHAP are done using wet methods, and the remaining 15 percent must use dry methods with other forms of asbestos control. Similarly, 95 percent of renovations performed in compliance with the NESHAP use wet removal methods and the remaining 5 percent use dry methods. Nationwide emissions are calculated as follows:

Emissions (kg/yr) = (Asbestos removed wet x wet removal emission factor)
+ (Asbestos removed dry x Dry removal emission factor).

Full compliance

Assuming full compliance, emissions were estimated to be

$$\text{Demolition emissions (kg/yr)} = 174{,}000 \text{ m}^3/\text{yr} \times .85 \times 2.7(10^{-4}) \text{ kg/m}^3 + 174{,}000 \text{ m}^3/\text{yr} \times .15 \times 9.5(10^{-4}) \text{ kg/m}^3 = 65 \text{ kg/yr}.$$

$$\text{Renovation emissions (kg/yr)} = 1{,}718{,}000 \text{ m}^3/\text{yr} \times .95 \times 2.7(10^{-4}) \text{ kg/m}^3 + 1{,}718{,}000 \text{ m}^3/\text{yr} \times .05 \times 9.5(10^{-4}) \text{ kg/m}^3 = 542 \text{ kg/yr}.$$

Current Practice

Currently, compliance with the NESHAP is less than 100 percent. It is estimated that about 80 percent of asbestos removal operations related to demolitions and about 80 percent of removals done as part of renovations are performed in compliance with the NESHAP.[20] Nationwide emissions were estimated to be as follows:

$$\text{Demolition emissions (kg/yr)} = (174{,}000 \text{ m}^3/\text{yr})(.8)(.85)(2.7\times10^{-4} \text{ kg/m}^3) + (174{,}000 \text{ m}^3/\text{yr})(.8)(.15)(9.5\times10^{-4} \text{ kg/m}^3) + (174{,}000 \text{ m}^3/\text{yr})(.2)(9.5\times10^{-4} \text{ kg/m}^3) = 85 \text{ kg/yr}.$$

$$\text{Renovation Emissions (kg/yr)} = (1{,}718{,}000 \text{ m}^3/\text{yr})(.8)(.95)(2.7\times10^{-4} \text{ kg/m}^3) + (1{,}718{,}000 \text{ m}^3/\text{yr})(.8)(.05) \times (9.5\times10^{-4} \text{ kg/m}^3) + (1{,}718{,}000 \text{ m}^3/\text{yr})(.2)(9.5\times10^{-4} \text{ kg/m}^3) = 744 \text{ kg/yr}.$$

NESHAP emissions are summarized in Table C-8.

C.3.2.1.2 Emissions under regulatory alternatives (assuming full compliance).

Negative Pressure/HEPA Filter System

Annual nationwide emissions under the alternative requiring negative pressure and HEPA filters on all jobs are calculated as follows:

Emissions (kg/yr) = (Asbestos removed wet x Wet removal plus HEPA emission factor) + (Asbestos removed dry x Dry removal plus HEPA emission factor).

For demolition and renovation annual emissions would be

$$\text{Demolition emissions (kg/yr)} = 174{,}000 \text{ m}^3 \times .85 \times 2.1(10^{-6}) \text{ kg/m}^3 + 174{,}000 \text{ m}^3 \times .15 \times 7.5(10^{-6}) \text{ kg/m}^3 = 0.51 \text{ kg/yr}.$$

TABLE C-8. NATIONWIDE ASBESTOS EMISSIONS (kg/yr) FROM ASBESTOS REMOVAL OPERATIONS--CURRENT THRESHOLD

Level of control	Demolition	Renovation
Current NESHAP (full compliance)	65	542
Current NESHAP (current practice)	85	744
Amended water	39	237
Negative pressure and HEPA, all removals	0.5	4
Amended water, negative pressure and HEPA, all removals	0.3	2

$$\text{Renovation emissions (kg/yr)} = 1{,}718{,}000\ m^3 \times .95 \times 2.1(10^{-6})\ kg/m^3 + 1{,}718{,}000 \times .05 \times 7.5(10^{-6})\ kg/m^3 = 4.1\ kg/yr.$$

Amended Water

Annual nationwide emissions under the alternative requiring the use of amended water are calculated as follows:

Emissions (kg/yr) = (Asbestos removed wet x Amended water emission factor) + (Asbestos removed dry x Dry removal emission factor).

For demolition and renovation, annual emissions would be

$$\text{Demolition emissions (kg/yr)} = 174{,}000\ m^3/yr \times .85 \times 9.5\ (10^{-5})\ kg/m^3 + 174{,}000\ m^3/yr \times .15 \times 9.5\ (10^{-4})\ kg/m^3 = 39\ kg/yr$$

$$\text{Renovation emissions (kg/yr)} = 1{,}718{,}000\ m^3/yr \times .95 \times 9.5(10^{-5})\ kg/m^3 + 1{,}718{,}000\ m^3/yr \times .05 \times 9.5(10^{-4})\ kg/m^3 = 237\ kg/yr.$$

Amended Water, Negative Pressure/HEPA Filter System

Annual nationwide emissions under the alternative requiring amended water and negative pressure and HEPA filters on all jobs are calculated as follows:

Emissions (kg/yr) = (Asbestos removed wet x Wet removal (amended water) plus HEPA emission factor) + (Asbestos removed dry x Dry removal plus HEPA emission factor).

For demolition and renovation annual emissions would be

$$\text{Demolition emissions (kg/yr)} = 174{,}000\ m^3 \times .85 \times 7.5\ (10^{-7})\ kg/m^3 + 174{,}000\ m^3 \times .15 \times 7.5\ (10^{-6})\ kg/m^3 = 0.31\ kg/yr$$

$$\text{Renovation emissions (kg/yr)} = 1{,}718{,}000\ m^3 \times .95 \times 7.5\ (10^{-7})\ kg/m^3 + 1{,}718{,}000\ m^3 \times .05 \times 7.5\ (10^{-6})\ kg/m^3 = 1.87\ kg/yr.$$

Emissions for the three regulatory alternatives are presented in Table C-8.

C.3.2.2 Nationwide Emissions from Sub-threshold Structures.

C.3.2.2.1 All sub-threshold structures. Estimates of asbestos emissions from demolition and renovation of structures containing less than threshold amounts of asbestos were made. Estimates of the numbers of jobs (demolitions and renovations) were multiplied by the amounts of asbestos removed (from a sub-threshold structure model plant, Chapter 5) and the emission factor for removals developed earlier in this appendix to estimate nationwide emissions.

In 1989 there were 3,326,896 1979 buildings (excludes residential structures having fewer than 10 units) in the United States.[21] At a demolition rate of 0.86 percent per year, 28,611 buildings are demolished each year.[22] Assuming that 20 percent of the buildings contain asbestos,[23] 28,611 x 0.2 equals 5,722 buildings containing asbestos that are demolished each year. The experience of the Puget Sound Air Pollution Control Agency, an agency that regulates all asbestos removals, is that 64 percent of projects involve amounts of asbestos less than the NESHAP thresholds.[24] The number of sub-threshold structures demolished per year is 5,722 buildings with asbestos x 0.64 = 3,662.

In FY88, EPA Regions II, IV, V, VI, and VII received a total of slightly more than 24,000 notifications as required by the NESHAP. Of these, 10 to 12 percent were for demolitions and 88 to 90 percent were for renovations, i.e., about nine renovations for each demolition.[25] The number of renovations per year is 3,622 x 9 = 32,598.

For FY89 the total number of notifications received for all of the United States was 68,029.[26] Assuming that 10 percent of notifications are for demolitions and 90 percent for renovations, there were 6,803 demolitions and 61,226 renovations in FY89. The number of sub-threshold structures demolished was 6,803 buildings x 0.64 = 4,354, and the number of renovations was 61,226 x 0.645 = 39,185.

In summary, it was estimated that between 3,662 and 4,354 sub-threshold structures were demolished in FY89 and that between 32,598 and 39,185 sub-threshold renovations were performed.

The corresponding amounts of asbestos material removed annually are 3,662 buildings x 1 m^3 = 3,662 m^3 to 4,354 buildings x 1 m^3 = 4,354 m^3 for demolitions, and 32,598 jobs x 0.5 m^3 = 16,299 m^3 to 39,185 x 0.5 m^3 = 19,593 m^3 for renovations. These ranges were averaged for use in subsequent calculations, i.e., 4,008 m^3 for demolitions and 17,946 m^3 for renovations.

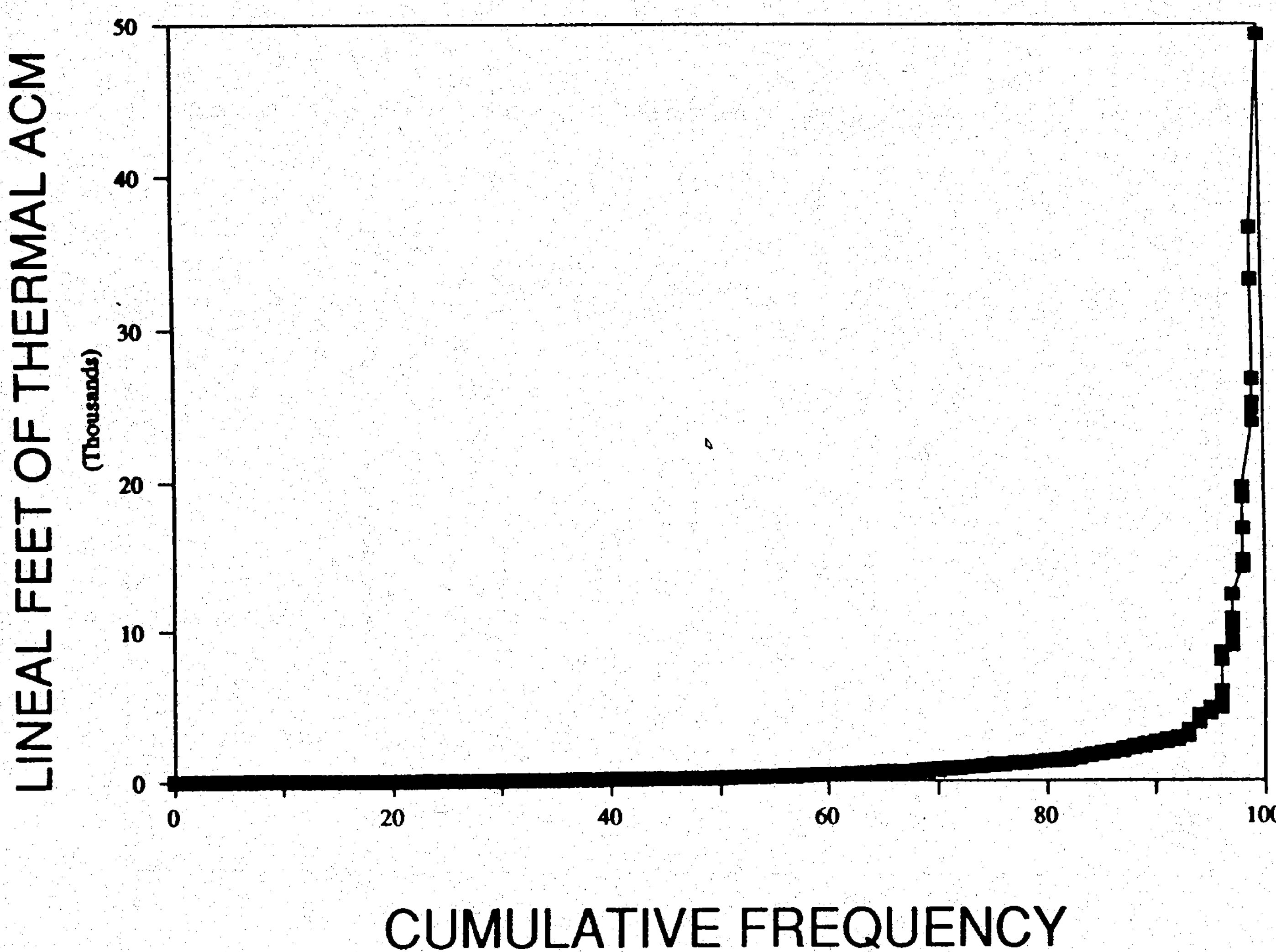

Figure C-2. Cumulative frequency distribution of thermal ACM in buildings in New York City.

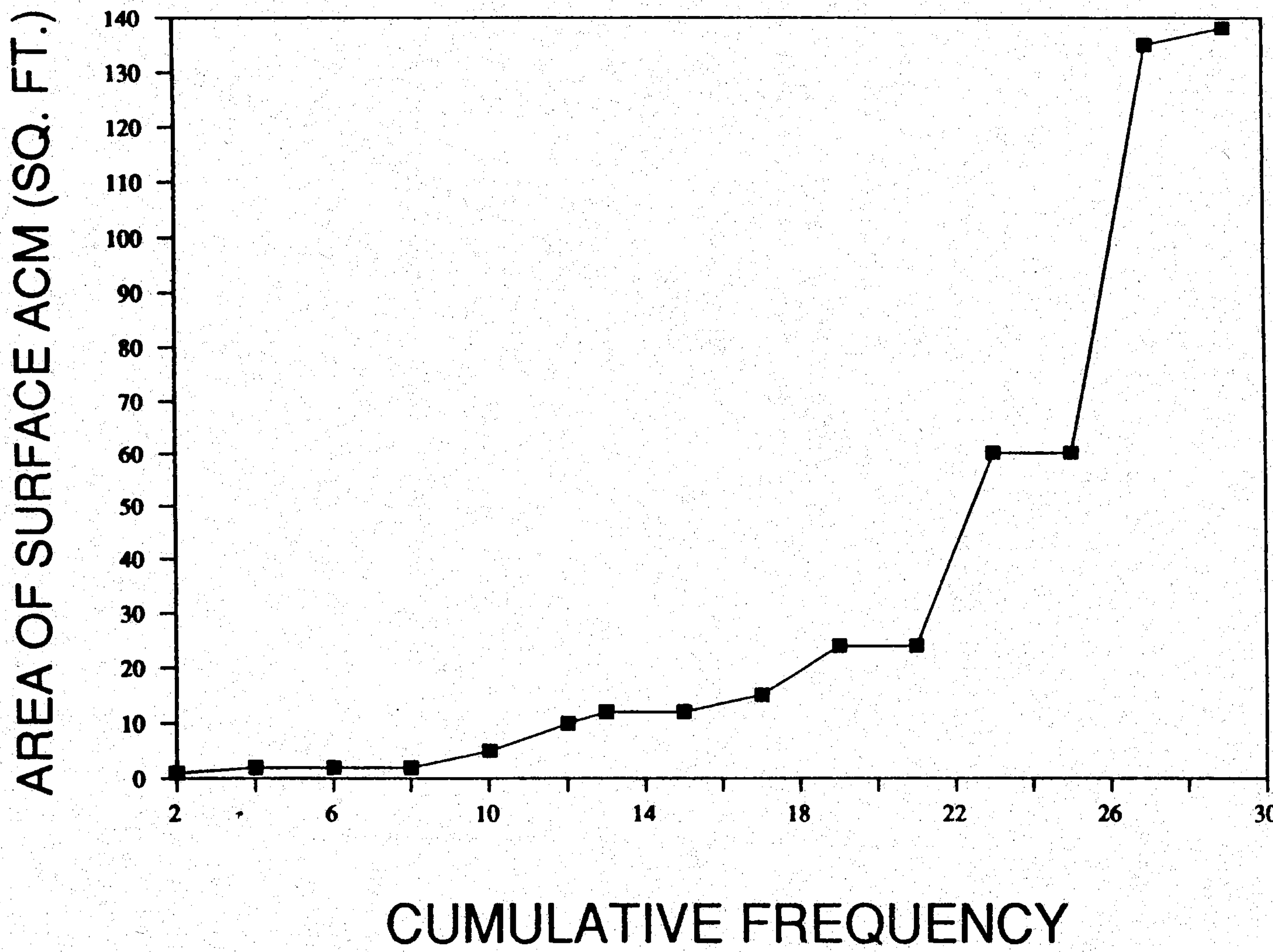

Figure C-3. Portion of cumulative frequency distribution of surface ACM in buildings in New York City.

Renovation emissions (kg/yr) = 9,898 m^3/yr (0.8)(0.95)(2.7 x 10^{-4} kg/m^3)
+ 9,898 m^3/yr (0.8)(0.05)(9.5 x 10^{-4} kg/m^3)
+ 9,898 m^3/yr (0.2)(9.5 x 10^{-4} kg/m^3)
= 4.3 kg/yr.

C.3.2.2.4 Emissions under regulatory alternatives.

Negative Pressure/HEPA Filter System

All Sub-threshold Structures

Annual nationwide emissions under the alternative requiring negative pressure and HEPA filters on all jobs are calculated as follows:

Emissions (kg/yr) = (Asbestos removed wet x wet removal plus HEPA emission factor) + (Asbestos removed dry x Dry removal plus HEPA emission factor).

For demolition and renovation, annual emission would be

Demolition emissions (kg/yr) = 4,008 m^3/yr x .85 x 2.1(10^{-6}) kg/yr
+ 4,008 m^3/yr x .15 x 7.5 (10^{-6}) kg/yr
= 0.012 kg/yr.

Renovation emissions (kg/yr) = 17,946 m^3/yr x .95 x 2.1 (10^{-6}) kg/yr
+ 17,946 m^3/yr x .05 x 7.5 (10^{-6}) kg/yr
= 0.043 kg/yr

Small-Scale, Short Duration Alternative

Nationwide emissions for demolitions and renovations smaller than the current NESHAP thresholds but equal to or greater than the quantities proposed by OSHA for small-scale, short duration jobs are calculated as follows:

Demolition emissions (kg/yr) = 2,211 m3/yr x .85 x 2.1 (10^{-6})kg/yr
+ 2,211 m3/yr x .15 x 7.5 (10^{-6})kg/yr
= 0.006kg/yr.

Renovation emissions (kg/yr) = 9,898 m3/yr x .95 x 2.1 (10^{-6})kg/yr
+ 9,898 m3/yr x .05 x 7.5 (10^{-6})kg/yr
= 0.023kg/yr.

Amended Water

All Sub-threshold Structures

Annual nationwide emissions under the alternative requiring the use of amended water are calculated as follows:

Emissions (kg/yr) = (Asbestos removed wet x Amended water emission factor)
+ (Asbestos removed dry x Dry removal emission factor).

For demolition and renovation, annual emissions would be

$$\text{Demolition emissions (kg/yr)} = 4{,}008\ m^3/yr \times .85 \times 9.5\ (10^{-5})\ kg/m^3 + 4{,}008\ m^3/yr \times .15 \times 9.5\ (10^{-4})\ kg/m^3 = 0.89\ kg/yr.$$

$$\text{Renovation emissions (kg/yr)} = 17{,}946\ m^3/yr \times .95 \times 9.5\ (10^{-5})\ kg/m^3 + 17{,}946\ m^3/yr \times .05 \times 9.5\ (10^{-4})\ kg/m^3 = 2.47\ kg/yr.$$

Small-Scale, Short Duration Alternative

Nationwide emissions for demolitions and renovations smaller than the current NESHAP thresholds but equal to or greater than the quantities proposed by OSHA for small-scale, short duration jobs are calculated as follows:

$$\text{Demolition emissions (kg/yr)} = 2{,}211\ m^3/yr \times .85 \times 9.5\ (10^{-5})\ kg/m^3 + 2{,}211\ m^3/yr \times .15 \times 9.5\ (10^{-4})\ kg/m^3 = 0.49\ kg/yr.$$

$$\text{Renovation emissions (kg/yr)} = 9{,}898\ m^3/yr \times .95 \times .95\ (10^{-5})\ kg/m^3 + 9{,}898\ m^3/yr \times .05 \times 9.5\ (10^{-4})\ kg/m^3 = 1.36\ kg/yr.$$

Amended Water, Negative Pressure/HEPA Filter System

All Sub-threshold Structures

Annual nationwide emissions under the alternative requiring amended water and negative pressure and HEPA filters on all sub-threshold jobs are calculated as follows:

Emissions (kg/yr) = (Asbestos removed wet x Wet removal (amended water) plus HEPA emission factor) + (Asbestos removed dry x Dry removal plus HEPA emission factor).

For demolition and renovation annual emissions would be

$$\text{Demolition emissions (kg/yr)} = 4{,}008\ m^3/yr \times .85 \times 7.5\ (10^{-7})\ kg/m^3 + 4{,}008\ m^3/yr \times .15 \times 7.5\ (10^{-6})\ kg/m^3 = 0.007\ kg/yr$$

$$\text{Renovation emissions (kg/yr)} = 17{,}946\ m^3/yr \times .95 \times 7.5\ (10^{-7})\ kg/m^3 + 17{,}946\ m^3/yr \times .05 \times 7.5\ (10^{-6})\ kg/m^3 = kg/yr\ 0.019\ kg/yr.$$

Small-Scale, Short Duration Alternative

Annual nationwide emissions for demolitions and renovations smaller than the current NESHAP thresholds but equal to or greater than the quantities proposed by OSHA for small-scale, short duration jobs are calculated as follows:

$$\text{Demolition (kg/yr)} = 2{,}211\ m^3/yr \times .85 \times 7.5\ (10^{-7})\ kg/m^3 + 2{,}211\ m^3/yr \times .15 \times 7.5\ (10^{-6})\ kg/m^3 = 0.0039\ kg/yr.$$

$$\text{Renovation (kg/yr)} = 9{,}898\ m^3/yr \times .95 \times 7.5\ (10^{-7})\ kg/m^3 + 9{,}898\ m^3/yr \times .05 \times 7.5\ (10^{-6})\ kg/m^3 = 0.0108\ kg/yr.$$

Nationwide emissions from sub-threshold asbestos removals are shown in Table C-9.

C.4 WASTE DISPOSAL EMISSIONS

C.4.1 Demolition and Renovation Waste

Emission factors were developed for the uncontrolled handling and disposal of asbestos-containing demolition and renovation debris. The emission factors were then used to estimate emissions for the various levels of regulatory control.

Emission factors were developed for the following waste disposal operations:

- Moving material at ground level to a temporary storage pile using a bucket loader
- Transferring debris from temporary storage to an open-bed truck using a bucket loader
- Dumping at the waste disposal site
- Leveling and compacting debris at the waste disposal site
- First-year wind erosion from the disposal site
- Subsequent years's wind erosion from the disposal site.

In developing the uncontrolled waste disposal emission factors, it was assumed that the asbestos was first removed from the structure and that the segregated asbestos-containing debris was handled dry and in bulk. It was also assumed that the material was left uncovered without vegetative covering after disposal.

Emission factors for asbestos waste disposal operations were developed using empirical equations for fugitive dust sources from EPA publication AP-42, Compilation of Air Pollutant Emission Factors.[28] None of the equations used were developed specifically for asbestos particulate matter or for emissions from demolition and renovation waste disposal operations.

TABLE C-9. NATIONWIDE ASBESTOS EMISSIONS (kg/yr) FROM ASBESTOS REMOVAL OPERATIONS--SUB-THRESHOLD

	Alternative threshold			
	$0\ ft^2$, 0 lin ft		$9\ ft^2$, 21 lin ft	
Level of control	Demolition	Renovation	Demolition	Renovation
Current practice	3.8	8	2.1	4.3
Amended water	0.89	2.47	0.49	1.36
Negative pressure and HEPA, all removals	0.012	0.043	0.006	0.023
Amended water, negative pressure and HEPA	0.007	0.019	0.004	0.011

However, in the absence of more specific data, use of the AP-42 equations was the only available method, however imperfect, of estimating emissions from demolition and renovation waste handling and disposal. The methodology originally used to estimate emissions was submitted for review to experts on fugitive emissions, affected industries, and environmental groups. Comments were used, as appropriate, to revise emission estimates. After further consideration, revisions were made to decrease the contribution of wind erosion. The equation used to estimate emissions from the movement of waste to a temporary storage pile, transfer of waste to a truck, and dumping at a disposal site was originally developed to estimate emissions from loading (batch drop) operations at steel slag and crushed limestone aggregate storage piles. Emissions from leveling and compacting operations at the disposal site were estimated using an empirical expression developed to estimate emissions from agricultural tilling. An emission factor equation for wind erosion from sand and gravel aggregate storage piles was used to develop emission factors for wind erosion of demolition and renovation debris at a waste disposal site.

The following empirical expressions from AP-42 were used:

Movement to a temporary storage pile, transfer of waste to a truck, and dumping at a disposal site

$$E = k(0.0016)\ [(U/2.2)^{1.3} \div (M/2)^{1.4}]\ \text{(kg/Mg of material dumped)}.$$

Leveling and compaction

$$E = k(5.38)(S)^{0.6}\ \text{(kg/ha of disturbed area)}\ .$$

Wind erosion

$$E = k\sum_{i=1}^{N} P \qquad \text{(kg/day/ha of material exposed)}$$

$$P = (u^{*}-u_{t}^{*})^{2} + 25(u^{*}-u_{t}^{*})$$

where

k = particle size multiplier from AP-42 expressed as a decimal fraction*

S = silt content of material being handled (percent by weight passing through a 200-mesh screen)

U = mean wind speed (m/s)

M = moisture content of material being handled (percent)

N = number of disturbances per year

P = erosion potential of eroding surface (g/m^2)

u^* = friction velocity (m/s)

u_t^* = threshold friction velocity (m/s).

For each equation, AP-42 specifies a range of values for the parameters corresponding to the climatic and other conditions that prevailed when the emission measurements were made that were used in developing the equation. In calculating emissions from demolition and renovation waste disposal, it was necessary to use some values outside the AP-42 suggested range.

No measured data were available for the silt content or the k value for demolition and renovation debris. For silt and moisture content, values outside the ranges specified in AP-42 but more appropriate for asbestos waste were used to estimate a range of emission factors. Limited test data on moisture content of asbestos material supports the range of values used for moisture content.[29] For k, the particle size multiplier from AP-42 for particles 30 μm or less in diameter was used since our interest was in particles that will remain airborne. Different k values would be used if we were interested in particulates of smaller or larger aerodynamic diameters. The values used for silt and moisture content and the k value were reviewed by experts on fugitive emissions and their comments incorporated into the analysis as appropriate. Representative mean wind speed was determined and was based on climatological data from the U.S. Department of Commerce. Wind speed values for the wind erosion equation were taken from AP-42. Values for asbestos content were based on

*k is the percent by weight of particles equal to or less than a specified aerodynamic diameter. The k value for particles 30 μm or less was selected for use since particles smaller than 30 μm in diameter have slow gravitational settling velocities and their settling is retarded by atmospheric turbulence.

values reported in a national survey of asbestos-containing structures.[30] Tables C-10 through C-12 list the parameters for each operation, the range of values used, and the emission factors calculated for each operation.

AP-42 suggests that emission factor quality ratings be assigned a value of D or E when the emission factor is extrapolated from another factor or a similar process. Because several extrapolations have been made, the three emission factor equations used here are probably not better than E, the lowest rating used.

The emission factors for waste handling and disposal were applied to the average amount of waste disposed of annually to calculate nationwide uncon- controlled emissions. It is projected that an average of about 521,000 m^3 of demolition waste and 5.15 million m^3 of renovation waste would be handled and disposed of each year for wastes subject to the NESHAP. Another 12,000 m^3 of demolition waste and 83,000 m^3 of renovation waste would be generated from sub-threshold structures and not subject to the NESHAP. Total wastes handled would be 532,000 m^3 for demolitions and 5.24 million m^3 for renovations.

C.4.1.1 NESHAP Emissions. Nationwide emissions under the NESHAP were developed for two situations: (1) full compliance with the NESHAP, and (2) current practice.

C.4.1.1.1 Full compliance. Assuming full compliance with the NESHAP, there would be no significant asbestos emissions from waste handling at the demolition and renovation site or from dumping and wind erosion at the disposal site since asbestos waste is typically wet and in bags and covered once a day. However, the current NESHAP does not prevent leveling and compaction of uncovered asbestos waste, which could burst bags and other containers of asbestos and result in the release of dry asbestos fibers. Based on information from disposal site operators and enforcement personnel, it was estimated that the uncontrolled emission factor for leveling and compaction would apply to 20 percent of the asbestos waste. But only waste that was removed dry would produce significant emissions. As noted earlier, an estimated 15 percent of demolitions and 5 percent of renovations involve dry removal of asbestos. Removals below the NESHAP threshold are estimated to be covered immediately for 95 percent of the waste. The remaining 5 percent would be subject to first-year erosion, and

TABLE C-10. PARAMETERS FOR DEVELOPING EMISSION FACTORS FOR UNCONTROLLED DUMPING AT DISPOSAL SITE

Parameter	Estimated value
Mean windspeed (m/s)	4.4
Moisture content (%)	2.6
Particle size multiplier	0.74
Density of waste (Mg/m^3)	0.4
Asbestos content (%)	15
Asbestos emission factor (kg/m^3)	1.21 (10^{-4})

TABLE C-11. PARAMETERS FOR DEVELOPING EMISSION FACTORS FOR UNCONTROLLED LEVELING AND COMPACTION

Parameter	Estimated value
Silt content (%)	10.7
Particle size multiplier	0.33
Asbestos content (%)	15
Depth of waste (m)	0.4
Emission factor (kg/m^3)	4.42 (10^{-3})

TABLE C-12. PARAMETERS FOR DEVELOPING FACTORS FOR UNCONTROLLED FIRST-YEAR WIND EROSION

Parameter	Estimated value
Asbestos content (%)	15
Fastest mile (m/s)	13.4
Threshold friction velocity (m/s)	0.58
Number of disturbances per year	1
Wastepile dimensions (m)	
Width at top	1.83
Length at top	6.10
Depth	0.4
(30° slope)	
Density of waste (Mg/m^3)	0.4
Emission factor (kg/m^3 yr)	3.44 (10^{-3})

60 percent of that amount would be subject to subsequent years' erosion. Equations for calculating nationwide emissions are given in Section C.4.1.1.2. Nationwide emissions for demolition and renovation wastes above threshold are calculated as follows and the results presented in Table C-13:

Emissions (kg/yr) = Asbestos removed dry (m^3/yr) x 0.2 x Emission factor (kg/m^3) for compaction.

For wastes above the threshold level, there would be no emissions from first-year or subsequent years' wind erosion since the waste would be covered immediately or very shortly after being placed in the disposal site.

C.4.1.1.2 Current practice. Based on the number of notifications received and without the advantage of precise information on the relationship between notification and compliance with the NESHAP, the Stationary Source Compliance Division estimates that compliance with the demolition and renovation provisions of the NESHAP is about 80 percent of full compliance for demolitions. For simplicity it is assumed that 80 percent compliance with the notification requirement also means that 80 percent of the waste volume is handled in accordance with the provisions of the NESHAP. Hence, it is estimated that 20 percent of the asbestos-containing material would not be removed first and segregated into asbestos and nonasbestos debris. Instead, the asbestos would be contained in the general demolition or renovation debris and would be treated as nonasbestos debris. There would be uncontrolled asbestos emissions from the transfer operations at the demolition and renovation site, dumping at the disposal site, and leveling and compaction. It is assumed that 95 percent of this nonsegregated, asbestos-containing debris would be covered immediately at the disposal site, precluding emissions due to first-year and subsequent years' wind erosion. The other 5 percent of the nonsegregated asbestos-containing debris would be disposed of along with general demolition and renovation debris and left exposed and subject to first-year and subsequent years' wind erosion. Figure C-5 illustrates the fate of demolition and renovation wastes under the NESHAP emission scenario assuming current practice. It is estimated that 40 percent of the out-of-compliance waste is covered within 1 year of being deposited, and 60 percent is left uncovered and subject to subsequent years' wind erosion.

TABLE C-13. ESTIMATED NATIONWIDE ASBESTOS EMISSIONS (kg/yr) FROM DEMOLITION AND RENOVATION WASTE DISPOSAL

Level of control	Demolition		Renovation	
	Below threshold	Above threshold	Below threshold	Above threshold
Current NESHAP (full compliance)	54.2	0.7	249	2.3
Current NESHAP (current practice)	54.2	470	249	3,084

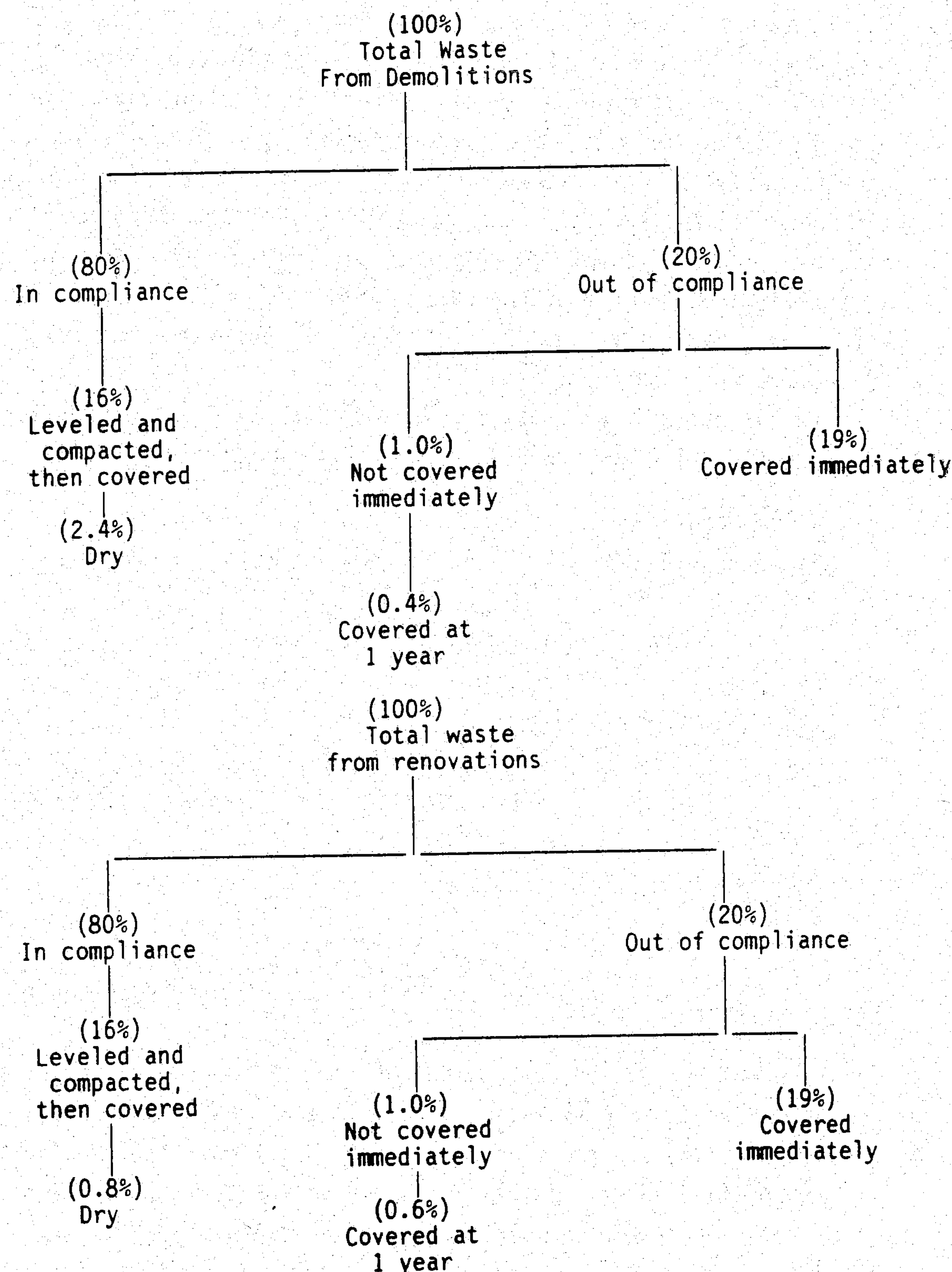

Figure C-5. Disposition of asbestos waste: current practice (as percent of total waste).

For renovations, it is estimated that due to OSHA and State regulations, 80 percent of the waste is handled in compliance with the NESHAP with emissions resulting only from the leveling and compaction of 20 percent of the dry waste deposited in landfills. The renovation waste handled out of compliance with the NESHAP will result in emissions during the uncontrolled transfer, dumping, and leveling and compacting operations and from renovation waste that is not covered. As with demolition waste, an estimated 40 percent of the out-of-compliance waste is covered soon after being deposited, and 60 percent is left uncovered and subject to subsequent years' wind erosion.

Annual nationwide asbestos emissions from each waste handling and disposal operation for demolition waste were estimated as follows:

Waste handling

Emissions (kg/yr) = total waste (m^3/yr) x 0.2 x Σ emission factors (kg/m^3) for transfers and dumping + total waste (m^3/yr) x 0.8 x 0.2 x 0.15 x emission factor (kg/m^3) for compaction.

First-year wind erosion

Emissions (kg/yr) = total waste (m^3/yr) x 0.2 x 0.05 x emission factor for first-year wind erosion (kg/m^3).

Subsequent year wind erosion

$$\text{Emissions (kg/yr)} = \frac{\sum_{n=1}^{77} n \times \text{total waste } (m^3/yr) \times 0.2 \times 0.05 \times 0.6 \times \text{emission factor } (kg/m^3) \text{ for subsequent years}}{78}.$$

Total annual nationwide emissions from demolition waste disposal are the sum of waste handling emissions and first and subsequent years' wind erosion emissions. Total emissions are presented in Table C-13.

Renovation waste disposal emission estimates are based on the assumption that, due to OSHA and other regulations, most asbestos from renovations would be handled in such a way as to minimize emissions. However, for reasons described earlier, 20 percent of renovation waste material would be expected to be handled and disposed of out of compliance with any regulation. The remaining 80 percent, removed and bagged in accordance with OSHA and other regulations, is likely to be properly handled and disposed of and covered soon after placement in a landfill. As with demolition waste, 20 percent of the material handled and disposed of properly still would be likely to produce emissions from the leveling and compaction of uncovered asbestos waste although only a small portion (5 percent) of renovation waste is removed dry and would produce significant emissions during leveling and compaction. Because of current disposal practices for nonasbestos material, it is estimated that of the 20 percent removed out of compliance, 95 percent would be covered immediately at the disposal site, and 5 percent would remain uncovered for 1 year and subject to first-year wind erosion. Of that 5 percent, 60 percent would be left uncovered and subject to subsequent year wind erosion. Annual nationwide asbestos emissions from each waste handling and disposal operation for renovation waste were estimated as follows:

Waste handling

Emissions (kg/yr) = total waste (m^3/yr) x .2 x Σ emission factors (kg/m^3) for transfer and dumping + total waste (m^3/yr) x .8 x .2 x .05 x emission factor (kg/m^3) for compaction.

First-year wind erosion

Emissions (kg/yr) = total waste (m^3/yr) x .2 x 0.05 x emission factor for first-year wind erosion (kg/m^3).

Subsequent year wind erosion*

$$\text{Emissions (kg/yr)} = \frac{\sum_{n=1}^{29} n \times \text{total waste (m}^3\text{/yr)} \times .2 \times 0.05 \times 0.6 \text{ emission factor (kg/m}^3\text{) for subsequent year erosion}}{78}$$

$$+ \frac{\text{total waste (m}^3\text{/yr)} \times .2 \times 0.05 \times 0.6 \times \text{emission factor (kg/m}^3\text{) for subsequent year erosion} \times 29 \times 49}{78}.$$

*It is projected that most major renovations will be completed over the next 29 years. Emissions will then continue until the 78th year at the level present during the 29th year. Total subsequent year emissions are divided by 78 years to get an annual average consistent with the rest of the analysis.

Total annual nationwide emissions from renovation waste disposal are obtained by summing the individual emissions from waste handling and first and subsequent years' wind erosion. Total emissions are presented in Table C-13.

C.4.1.1.3 With regulatory alternatives. The alternative to require 3 in. of cover on waste prior to leveling and compacting will essentially eliminate emissions from that activity. Assuming full compliance with the NESHAP, emissions would be reduced by approximately 0.2 kg/yr from demolition waste and 0.8 kg/yr from renovation waste.

C.4.2 Milling, Manufacturing, and Fabricating Waste

Emission factors were developed to estimate emissions from milling, manufacturing and fabricating waste disposal. Controlled emission estimates for milling, manufacturing, and fabricating are summarized in Table C-14.

For mills, the waste handling operations are as follows:

- Transfer of control device and process tailings onto and between conveyor systems
- Dumping of control device and process tailings from the conveyor system to the wastepile
- First-year wind erosion from the wastepile
- Subsequent years' wind erosion from the wastepile.

All of the data used to develop emission factor estimates for mills were taken from nonconfidential data on the mills or were estimated.

Controlled emissions were estimated using the emission factors for NESHAP controlled mill waste shown in Table C-15. The emission factors assume that there are no emissions from transfer and dumping of mill waste as a result of the use of dust suppressants. The emission factors for wind erosion assume no control. It is likely that actual values would be much less than the values of Table C-15 because of the use of dust suppressants, the growth of vegetation, and crusting.

The wind erosion emission factors were estimated using the following equation from the 1983 edition of AP-42, Compilation of Air Pollutant Emission Factors, Section 11.2.[31] This equation was used in preference to more recent equations because of confidential data considerations.

TABLE C-14. WASTE DISPOSAL EMISSIONS FOR MILLING, MANUFACTURING AND FABRICATING, 1989

Source	Emissions (kg/yr)
Milling	22
Manufacturing	
Friction	7.4
A/C pipe	0.7
A/C sheet	0.6
Paper	0.1
Coatings, sealants	0.1
Plastics	0.4
Textiles	0.1
Packings, gaskets	0.03
V/A tile	0.1
Other	0.01
Fabricating	0.4
Total	32

TABLE C-16. PARAMETERS FOR DEVELOPING EMISSION FACTORS FOR ASBESTOS MILL WASTE

	Mill		
	A	B	C
Estimated mixed mill tailing and dust collector waste silt content (percent)	15	15	15
Silt content for first-year wind erosion equation (percent)	2	2	2
Silt content for subsequent years' erosion (percent)	1.5	1.5	1.5
Estimated moisture content (percent)	0.64	0.64	0.64
Estimated drop height for conveyor transfer points (m)	1.5	1.5	1.5
Estimated drop height for transfer to storage pile (m)	6.0	6.0	6.0
Estimated number of conveyor transfer points	13	--	10
Estimated number of days with rainfall exceeding 0.01 in.	150	60	60
Estimated mean wind speed (m/s)	4.44	4.44	4.44
Estimated percent of time wind speed exceeds 5.4 m/s	24	8	24
Estimated height of storage pile (m)	120	20	120
Estimated bulk density of waste (Mg/m^3)	1.602	1.602	1.602
Value of K for continuous drop equation from AP-42	0.77	0.77	0.77

TABLE C-17. EMISSION FACTORS FOR UNCONTROLLED LEVELING AND COMPACTING OF MANUFACTURING AND FABRICATION WASTES

	Estimate emissions
Silt content (%)	96
Particle size multiplier	1.0
Depth of waste (m)	3
Emission factor (kg/Mg)	0.0156

TABLE C-18. EMISSION FACTORS (KILOGRAMS OF PARTICULATE PER MEGAGRAM OF WASTE)[a] FOR NESHAP CONTROLLED DISPOSAL OF MANUFACTURING AND FABRICATING WASTES

Operation	Emission factors (kg/Mg)
Hopper drop and transfer to bucket loader (two operations)	0
Dumping bucket loader into truck	0
Dumping truck at waste disposal site	0
Leveling and compaction	0.0031
First-year wind erosion	
Subsequent years' erosion per year	0

[a]The emission factors should be multiplied by $\frac{\text{Asbestos content (percent)}}{100}$ to estimate asbestos emissions.

The parameters evaluated and the value used in developing emission factors are presented in Table C-17.

Table C-18 shows estimated emission factors for controlled manufacturing and fabricating source waste disposal. The emission factors were applied to confidential data on individual plant dust collector waste to estimate individual source emissions, which were aggregated to protect confidentiality. The emissions were then revised to 1989 by adjusting for decreases in U.S. production since the confidential data were obtained. Table C-14 shows emission estimates for controlled manufacturing and fabricating waste disposal.

C.4.2.1 Emissions Under Regulatory Alternatives

The primary source of waste disposal emissions associated with waste from manufacturing and fabricating is from uncontrolled leveling and compaction of waste. Emissions from leveling and compaction are shown in Table C-14. Under the alternative to require 3 in. of cover on waste prior to leveling and compacting, emissions associated with manufacturing and fabricating will be reduced by 10 kg/yr. Emissions from milling will not be affected because leveling and compacting are not part of waste disposal practices at mills.

C.5 REFERENCES

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APPENDIX D

PROCEDURE FOR MEASURING THE SURFACE TENSION OF AMENDED WATER

APPENDIX D

PROCEDURE FOR MEASURING THE SURFACE TENSION OF AMENDED WATER

D.1 PRINCIPLE

The surface tension of a liquid is measured by the capillary-rise method. When a capillary tube is immersed in a liquid, the liquid will rise in the tube as a function of the liquid's surface tension. This rise is balanced by the downward force due to gravity. Given the diameter of the capillary, the gravitational constant, and the density of the liquid, the surface tension can be calculated from the measured height of the liquid rise.

D.2 APPARATUSES

The following apparatuses are required for sampling and analysis.

D.2.1 Filtration System

Some very dirty samples may require filtration before the surface tension can be measured. One convenient way to accomplish this is to use a disposable syringe equipped with a disposable filter assembly containing a hydrophilic filter with a 5.0-μm pore size. Other filtration systems would be acceptable as long as they are capable of removing suspended solids from the sample.

D.2.2 Glass Capillary Tube

The tube shall be graduated from 0 to 10 cm in 1-mm increments and supported inside an outer glass tube by means of a rubber stopper or cork (see Figure D-1). The outer tube must have a sidearm that can accept rubber or plastic tubing. A suitable apparatus can be purchased from Fisher Scientific Company, 711 Forbes Avenue, Pittsburgh, Pennsylvania 15219.

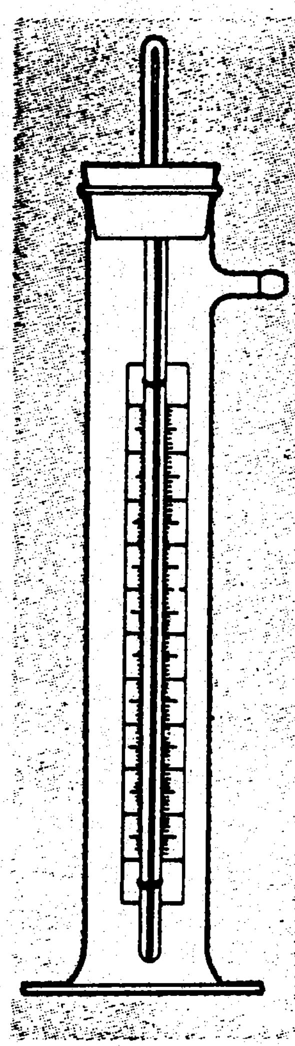

Figure D-1. Surface tension apparatus.

D.3 REAGENTS

The following reagents are required for analysis.

D.3.1 Distilled Water

Use this water in all applications.

D.3.2 Chromic Acid Cleaning Solution

Use commercially available chromic acid solution or prepare as follows: Mix 70 to 75 g of sodium dichromate with about 35 mL of water in a 2-L flask. Slowly add 1 L of concentrated sulfuric acid with thorough mixing. The solution may be reused until it turns green, at which time it should be discarded.

D.3.3 Methanol

Use reagent grade.

D.3.4 Alcoholic Potassium Hydroxide

Pour 200 mL of absolute ethanol into one 500-mL flask. Dissolve 10 g of potassium hydroxide in the alcohol.

D.4 PROCEDURE

D.4.1 Preparation

It is essential that the analytical apparatus be scrupulously clean. Before its first use, the equipment must be cleaned with chromic acid solution, followed with a water rinse, a methanol rinse, and another water rinse. After cleaning the apparatus, test for cleanliness according to the procedure described in Section D.4.2.

D.4.2 Cleanliness Check

Place at least 100 mL of water in the outer tube and assemble the apparatus. Attach a length of tubing to the sidearm of the outer tube and blow into the tubing so that the sample moves freely up and down the length of the capillary and the capillary walls are thoroughly wetted. Allow the liquid level in the capillary to come to equilibrium. Measure and record, in millimeters, the difference in height of the liquid in the capillary column and the height of the liquid in the outer tube.

Next, suck into the tubing and allow the liquid level in the capillary to come to equilibrium. Measure and record, in millimeters, the difference in height of the liquid in the capillary and the height of the liquid in the outer tube. Compare this reading to the previous reading. A difference of more than ±2 mm in the two readings indicates that the capillary is dirty.

If the capillary is dirty, repeat the cleaning procedure described in Section D.4.1 and repeat the cleanliness check. If the capillary is still dirty, rinse it with the alcoholic potassium hydroxide solution (see Section D.3.4) and repeat the cleanliness check. The capillary must be able to pass the cleanliness check before any samples are measured.

D.4.3 Analysis

Follow the procedure described in Section D.4.2, but substitute 100 mL of sample for the water. Repeat the procedure twice for a total of four readings. Average the four readings and record this value.

D.4.4 Calculations

Use the following equation to calculate the surface tension of the sample:

$$\gamma = \frac{hrdg}{20}$$

where

γ = Surface tension of the liquid, dynes/cm

h = Height of the liquid in the capillary above the liquid level in the outer tube, mm

r = Radius of the capillary, cm

d = Density of the sample at the measuring temperature, g/cm^3*

g = Acceleration due to gravity, 981 cm/s^2.

*Assume a density of 1 g/cm^3. If necessary, density can be determined using ASTM Method D 1429-76.

APPENDIX E

DETAILED ANALYSIS OF REGULATORY BASELINE

TABLE 1. COMPARISON OF REGULATORY BASELINE AND ALTERNATIVES FOR ASBESTOS MILLING, MANUFACTURING, AND FABRICATING

REGULATORY BASELINE	REGULATORY ALTERNATIVES[1]			
	HEPA FILTERS	VE LIMIT AND EQUIPMENT SPECS	MALFUNCTIONS	IMPORT/EXPORT
FEDERAL				
EPA NESHAP (40 CFR 61, Subpart M)	NO[2]	NO[2]	NO[2]	NO
EPA TSCA Ban (40 CFR 273, Subpart I)	NO	NO	NO	YES[3]
DOT (49 CFR 171)	NO	NO	NO	YES[4]
OSHA Workplace (29 CFR 1910.1001 Subpart Z)	NO[5]	NO	NO	NO
STATES	NO (0/51)	YES[6] (2/51)	NO (0/51)	NO (0/51)

CODE: "NO" means that the existing rule does not contain the requirements addressed by a regulatory alternative. "YES" means that the existing rule does contain the requirements. For States, the number of states with regulations similar to or the same as the regulatory alternative is shown in parentheses.

1 See Attachment 1 for description of regulatory alternatives.

2 The EPA NESHAP requires no visible emissions or compliance with air cleaning equipment specifications (i.e., baghouses). No provisions for malfunctions are included.

3 The TSCA Ban and Phasedown regulation (40 CFR 763, Subpart I) prohibits the manufacture, importation, and processing of specified asbestos products on schedule from August 1990 to August 1997.

4 The DOT regulations for asbestos also apply to imported commercial asbestos (49 CFR 171.12).

5 The OSHA workplace standard requires any of a combination of equipment controls, such as local exhaust ventilation, and work practices to meet exposure levels. The standard does not include provisions for exhaust streams from ventilation systems.

6 Colorado requires no visible emissions <u>and</u> equipment specifications (air cleaning) for milling, manufacturing, and fabricating operations. Illinois requires no visible emissions of particulate matter from a factory, plant, or enterprise engaging in the processing or manufacturing of any asbestos-containing product <u>and</u> limits concentrations of asbestos fiber into the ambient air to no more than 2 f/cc.

ATTACHMENT 1. DESCRIPTION OF REGULATORY ALTERNATIVES

HEPA FILTERS. This alternative would require HEPA filters on the exhaust streams of all air-cleaning devices as final filters.

VISIBLE EMISSION (VE) LIMIT AND EQUIPMENT SPECIFICATIONS. This alternative would require no visible emissions and compliance with equipment specifications.

MALFUNCTIONS. This alternative would require that malfunctioning control devices be shut down and repaired prior to returning to operation.

IMPORT/EXPORT. This alternative would regulate the import and export of facility components containing asbestos.

TABLE 1A. COMPARISON OF STATE REGULATIONS AND REGULALTORY ALTERNATIVES FOR ASBESTOS MILLING, MANUFACTURING, AND FABRICATING

STATE BASELINE	REGULATORY ALTERNATIVES HEPA FILTERS	VE LIMIT AND EQUIPMENT SPECS	MALFUNCTIONS	IMPORT/EXPORT
Alabama	NO	NO	NO	NO
Alaska	NO	NO	NO	NO
Arizona	NO	NO	NO	NO
Arkansas	NO	NO	NO	NO
California	NO	NO	NO	NO
Colorado	NO	YES[1]	NO	NO
Connecticut	NO	NO	NO	NO
Delaware	NO	NO	NO	NO
District of Columbia	NO	NO	NO	NO
Florida	NO	NO	NO	NO
Georgia	NO	NO	NO	NO
Hawaii	NO	NO	NO	NO
Idaho	NO	NO	NO	NO
Illinois	NO	YES[2]	NO	NO
Indiana	NO	NO	NO	NO

STATE BASELINE	HEPA FILTERS	REGULATORY ALTERNATIVES VE LIMIT AND EQUIPMENT SPECS	MALFUNCTIONS	IMPORT/EXPORT
Iowa	NO	NO	NO	NO
Kansas	NO	NO	NO	NO
Kentucky	NO	NO	NO	NO
Louisiana	NO	NO	NO	NO
Maine	NO	NO	NO	NO
Maryland	NO	NO	NO	NO
Massachusetts	NO	NO	NO	NO
Michigan	NO	NO	NO	NO
Minnesota	NO	NO[3]	NO	NO
Mississippi	NO	NO	NO	NO
Missouri	NO	NO	NO	NO
Montana	NO	NO	NO	NO
Nebraska	NO	NO	NO	NO
Nevada	NO	NO	NO	NO
New Hampshire	NO	NO	NO	NO
New Jersey	NO	NO	NO	NO
New Mexico	NO	NO	NO	NO

STATE BASELINE	REGULATORY ALTERNATIVES HEPA FILTERS	VE LIMIT AND EQUIPMENT SPECS	MALFUNCTIONS	IMPORT/EXPORT
New York	NO	NO	NO	NO
North Carolina	NO	NO	NO	NO
North Dakota	NO	NO	NO	NO
Ohio	NO	NO	NO	NO
Oklahoma	NO	NO	NO	NO
Oregon	NO	NO	NO	NO
Pennsylvania	NO	NO	NO	NO
Rhode Island	NO	NO	NO	NO
South Carolina	NO	NO	NO	NO
South Dakota	NO	NO	NO	NO
Tennessee	NO	NO	NO	NO
Texas	NO	NO	NO	NO
Utah	NO	NO	NO	NO
Virginia	NO	NO	NO	NO
Vermont	NO	NO	NO	NO
Washington	NO	NO	NO	NO
West Virginia	NO	NO	NO	NO

STATE BASELINE	REGULATORY ALTERNATIVES HEPA FILTERS	VE LIMIT AND EQUIPMENT SPECS	MALFUNCTIONS	IMPORT/EXPORT
Wisconsin	NO	NO	NO	NO
Wyoming	NO	NO	NO	NO

CODE: "NO" means that the existing rule is the same as or equivalent to existing Federal rules and does not contain the requirements addressed by a regulatory alternative. "YES" means that the existing rule does contain the requirement of a regulatory alternative.

1 Each owner or operator of an asbestos mill, manufacturing operation, or fabricating operation shall discharge no visible emissions to the ambient air and use the specified methods for air cleaning before particulate asbestos material escapes to or are vented to the ambient air (Regulation No. 8, Section D).

2 No VE of particulate matter can be discharged into the ambient air from manufacturing or processing and concentrations of asbestos fiber emitted into the ambient air can not exceed 2 f/cc of air (Title 35, Subpart E, Section 228.151).

3 Emissions of particulate matter to the atmosphere from a local exhaust ventilation system from a building, structure, facility, or installation within which any manufacturing operation is carried on shall not exceed the amount that would be emitted if such emissions were treated in a fabric filter installation. Fabric filter devices do not meet requirements if any of the following conditions exist: leakage of gases containing particulate matter from the control system prior to filtration, torn or ruptured bags, improperly positioned bags, badly worn or threadbare bags, or the presence of visible emissions of particulate matter during the emptying of collection hoppers. Wet collectors do not meet requirements as a substitute if any of these conditions exist: leakage of gases containing particulate matter from the system prior to passage through the wet collector or operation at a gas static pressure head decrease, a scrubbing medium flow rate, or a mechanical energy level less than specified by the manufacturer for optimum collection efficiency. (Rule 7005.1590). The total mass collection efficiency of any substitute device for a fabric filter shall not be less than 99.9 percent and 99.5 percent for any substitute device for a wet collector (Rule 7005.1600).

TABLE 2. COMPARISON OF STATE REGULATIONS AND ALTERNATIVES FOR ASBESTOS DEMOLITION AND RENOVATION

REGULATORY BASELINE	REGULATORY ALTERNATIVES[1]										
	THRESH-HOLD	HEPA FILTERS	WETTING AGENTS	VIEWING PORTS	NOTIFI-CATION	TRAIN-ING	BULK SAMPLING	ADEQUATE REMOVAL	MAINTE-NANCE	NON-FRIABLE	RUN-OFF
FEDERAL											
EPA NESHAP (40 CFR 61, Subpart M)	YES	NO	NO	NO	YES	NO	NO	NO	NO	NO	NO
OSHA Con-struction (29 CFR 1926.58)	NO[2]	YES[3]	YES[4]	NO[5]	NO	YES[6]	NO[7]	NO	NO	NO[8]	NO
EPA AHERA (40 CFR 763, Subpart E)	NO[9]	YES[10]	YES[11]	NO	NO[12]	YES[13]	YES[14]	YES[15]	YES[16]	YES[17]	NO
EPA AHERA (40 CFR 763, Subpart F)	NO[18]	NO	NO	NO	NO[19]	NO	YES[20]	NO	NO	NO[21]	NO
EPA AHERA (40 CFR 763, Subpart G)	NO[22]	NO[23]	NO[24]	NO	NO[25]	YES[26]	NO[27]	NO	NO	NO[28]	NO
STATES	YES[29] (25/51)	YES[30] (22/51)	YES[31] (13/51)	NO[32] (0/51)	YES[33] (38/51)	YES[34] (47/51)	YES[35] (5/51)	YES[36] (22/51)	YES[37] (10/51)	YES[38] (2/51)	YES[39] (7/51)

CODE: "NO" means that the existing rule does not contain the requirements addressed by the regulatory alternative. "YES" means that the existing rule does include a provision similar to or the same as the regulatory alternative.

1 See Attachment 1 for description of regulatory alternatives.

2 Proposed revisions to 29 CFR 1926.58 (55 FR 29712, July 20, 1990) would establish a permissible exposure limit of 0.1 f/cc. Unless specifically exempted, negative pressure enclosures would be required for all removal, demolition, and renovation operations regardless of the exposure level. However, the proposed definition for small-scale, short duration operations includes specific tasks described in terms of the timeframe required for completion and/or the amount of asbestos disturbed or area of operations.

3 Proposed revisions to 29 CFR 1926.58(e)(6) would require the use of negative pressure enclosures for all removal, demolition, and renovation operations except for small scale, short duration operations, operations where the erection of the enclosures are infeasible due to the configuration of the work area, and roofing removal jobs. Appendix F to 40 CFR 1926.58 (not mandatory under the existing standard) would become mandatory. Appendix F states that exhaust air filtration systems that create negative pressure inside the enclosure must be equipped with HEPA filters. The ventilation system should be operated 24-hours per day during the entire project. Small-scale, short-duration operations exempt from the requirement would include only those demolition, renovation, repair, maintenance, and removal operations which are nonrepetitive, affect small surfaces or volumes of material, and which are to be completed within short timeframes. For exempt operations, alternative feasible containment or enclosures, such as glove bags or minienclosures, must be used and feasible wet methods must be used to handle, disturb, and/or remove asbestos. The provisions in Appendix G would become mandatory. Appendix G recommends that one or a combination of controls and work practices be used, including wet methods, removal methods (glove bags, removal of pipe or structure, minienclosures), enclosure of materials, and maintenance programs. For glove bag methods, HEPA filtered vacuums are recommended equipment for evacuation of the glove bag.

4 Proposed revisions to 29 CFR 1926.58(e) would require that Appendix F to 29 CFR 1926.58, which provides guidelines for negative pressure enclosures, become mandatory. Appendix F recommends wetting and the use of wetting agents applied with airless sprayers. The specific types of wetting agents to be used are not specified. For small-scale, short duration operations, the proposed revisions would require that feasible wetting methods be used in conjunction with equipment controls. Appendix G would become mandatory. Appendix G states that wet methods must be used wherever feasible, regardless of the abatement method use. For glove bag methods, amended water or other wetting agents are recommended. The amended water or wetting agent should be applied with an airless sprayer. Wetting agents are not specified.

5 Proposed revisions to 29 CFR 1926.58 would make Appendix F mandatory. Appendix F to 29 CFR 1926.58 provides guidelines for negative pressure enclosures. While the guidelines provide for an opening in the enclosure for airless sprayers, no provision for viewing ports is included. No provision for viewing ports are included in the guidelines of Appendix G for short term small scale operations.

6 29 CFR 1926.58(k)(3) requires a training program for all employees exposed to airborne asbestos in excess of the action level and/or excursion limit. Training must be provided prior to or at the time of initial assignment (unless the employee has received equivalent training within the previous 12 months) and at least annually thereafter. Proposed revisions would require a competent person to oversee all removal, demolition, and renovation operations. A comprehensive training course would be required for persons overseeing large scale jobs, and an appropriate training course would be required for the person overseeing small scale, short duration operations.

7 29 CFR 1926.58 requires personal zone sampling and analysis to determine compliance with occupational exposure limits. Appendix A specifies mandatory procedures for sampling and analysis. Fiber counts must be made using positive phase contrast microscopy (NIOSH 7400). Nonmandatory Appendix B provides additional details on procedures for phase contrast microscopy. Bulk sampling is not required.

8 29 CFR 1926.58 does not contain different requirements for nonfriable asbestos.

9 40 CFR 763, Subpart E applies to asbestos containing material containing more than one percent asbestos by weight. However, the regulation does not establish a threshold level of asbestos for response actions (i.e., any amount of asbestos containing material identified is subject to response actions). However, 40 CFR 763.91(f)(2) defines a major fiber release episode as the falling or dislodging of 3 square or linear feet or less of friable asbestos containing materials. Response actions for a major fiber release episode must be designed and conducted by accredited persons. Accredited persons are not required for minor fiber release episodes. Appendix B to Subpart E provides guidelines for small-scale, short duration operations based on OSHA Appendix G to 29 CFR 1926.58 that may be used as an alternative. This appendix provides additional definitions of small-scale, short duration operations, but does not define "small" in terms of a numerical threshold level (e.g., not to exceed amounts greater than can be contained in a single glove bag for removal of asbestos-containing thermal system insulation, not to exceed amounts that can be contained in a single prefabricated minienclosure for repairs involving encapsulation, enclosure or removal).

10 40 CFR 763.91(b) extends the AHERA worker protection rules of 40 CFR 763.121 to maintenance and custodial personnel in schools who perform operation and maintenance (O & M) jobs but were not covered by OSHA rule or OSHA approved State plans. Appendix B to 40 CFR 763, Subpart E adapts OSHA Appendix G for small scale, short duration projects conducted by O & M personnel. The guidelines recommend that one or a combination of controls and work practices be used, including wet methods, removal methods (glove bags, removal of pipe or structure, minienclosures), enclosure of materials, and maintenance programs. For glove bag methods, HEPA filtered vacuums are recommended equipment for evacuation of the glove bag.

11 Appendix B to 40 CFR 763 Subpart E is provided as an alternative to the worker protection requirements of 40 CFR 763.121 for LEA employees performing small scale, short duration operations. Appendix B requires wetting during small scale short duration maintenance and renovation jobs whenever feasible and regardless of the abatement method used. Amended water or another wetting agent should be applied with airless sprayers.

12 40 CFR 763, Subpart E does not require the accredited inspector to notify EPA prior to beginning abatement operations. The rule does require the management plan developer to report the results of each assessment, including the recommended response action, to the LEA. Also, the LEA must notify parent, teacher, and employee organizations of the availability of the management plan and inform workers and building occupants about inspections and response plans at least on an annual basis.

13 40 CFR 763.92(a) requires that all O & M staff who work in a building that contains asbestos (friable or nonfriable) receive at least two hours of awareness training whether or not they work with asbestos. New employees must be trained within 60 days of beginning work. All O & M staff that conduct any activities that result in disturbance of asbestos-containing material must receive an additional 14 hours of training. Persons who have attended EPA-approved training or the equivalent are not required to receive any more training.

14 40 CFR 763.86 requires that an accredited inspector collect bulk samples to determine if friable asbestos is present. 40 CFR 763.87 requires analysis of the bulk samples by an NBS-accredited laboratory. Analysis of bulk samples is by PLM. An area is considered to contain asbestos if asbestos is present in any sample in a concentration greater than one percent.

15 40 CFR 763.90(i) requires air testing to determine if a response action has been completed (except for small-scale, short duration operations). PCM is allowed for response actions involving 260 linear or 160 square feet or less. TEM is required for most removal, enclosure, and encapsulation jobs. A two year phase in period period (allowing the use of PCM during that period) is allowed. Until December 14, 1990, PCM can be used for projects of 1,500 square or 500 linear feet or less. When using PCM, a minimum of five samples is required; all samples must be below the limit of reliable quantification of the method (0.01 f/cc). NIOSH Method 7400 must be used for PCM clearance. For TEM, a sequential evaluation of five samples taken inside the worksite and five samples taken outside the worksite is required. For the inside samples, the average concentration of the inside sample can not exceed the filter background contamination level. If the average concentration of the inside samples is greater than the filter background contamination level, the outside samples must be analyzed. In this case, an encapsulation, enclosure, or removal response action is considered complete when the average of the five inside samples is not significantly larger than the average of the five samples taken outside the worksite, based on a statistical Z-test. Detailed TEM procedures are included in Appendix A to Subpart E.

16 40 CFR 763.90 requires response actions for asbestos containing building materials with the potential for damage. When potential damage is possible, the LEA must implement an O & M program.

17 40 CFR 763.90 establishes different responses for different categories of damaged or potentially damaged asbestos containing material that are friable. 40 CFR 763.91 also requires that an O & M program be established for any school building with friable asbestos. Requirements for periodic inspections and training apply to friable and nonfriable asbestos containing material (40 CFR 763.92).

18 The inspection and sampling requirements in 40 CFR 763, Subpart F apply only to any amount of friable asbestos containing materials (materials containing more than one percent asbestos by weight).

19 40 CFR 763.111 requires the local educational agency to notify school employees if friable asbestos has been identified; 40 CFR 763.114 requires the local educational agency to maintain records of the inspection and analytical results. The rule does not require notification to EPA.

20 40 CFR 763.107 requires a minimum of three samples of friable materials identified in the inspection. The samples must be analyzed by PLM, supplemented where necessary by x-ray diffraction.

21 The inspection, sampling, and analysis requirements apply only to friable asbestos.

22 40 CFR 763, Subpart G establishes requirements for State and local government workers not covered by the OSHA construction standard or OSHA-approved State rules who perform asbestos abatement (i.e., removal, enclosure, or encapsulation of friable materials) jobs. Subpart G adopts the 1986 OSHA permissible exposure level of 0.2 f/cc (8-hour time weighted average) with an action level of 0.1 f/cc. The existing standard has not yet been revised to incorporate recent changes to the OSHA standard (e.g., adoption of the short term exposure limit) or proposed changes to the OSHA permissible exposure limit and engineering controls/work practices (see Footnote 2). Accordingly, a regulated work area must be established whenever asbestos concentrations exceed, or are expected to exceed, the permissible exposure limit. Daily monitoring is not required if employee exposure is below the action level. The standard does not establish a numerical threshold for the amount of asbestos involved in the abatement action that triggers other requirements.

23 40 CFR 763(g) is based on the 1986 OSHA standard. Currently, a negative pressure enclosure is required wherever feasible for removal, demolition, and renovation operations. 40 CFR 763.121(g) allows the use of one or a combination of the following methods to achieve compliance: (1) local exhaust ventilation equipped with HEPA filter dust collection systems, (2) general ventilation systems, (3) vacuum cleaners equipped with HEPA filters, (4) enclosures or isolation of processes producing asbestos dust, (5) use of wet methods, wetting agents, or removal encapsulants, (6) prompt disposal of wastes in leak-tight containers, and (6) other feasible work practices and engineering controls. Small scale, short duration operations are exempt.

24 40 CFR 763(g) does not require the use of wet methods or wetting agents, although this is one method of compliance allowed by the rule.

25 40 CFR 763(f)(6) requires notification to employees of monitoring results. However, Subpart G does not require notification to EPA of the abatement job or notification to employees that friable asbestos has been identified.

26 40 CFR 763(j)(3) requires a training program for all employees exposed at or above the action level. Training must be given prior to at at the time of initial assignment (unless the employee has received equivalent training within the previous 12 months) and at least annually after that time. 40 CFR 763.121(e)(6) requires that a competent person supervise the negative pressure enclosure; the competent person must be trained by a comprehensive course or the equivalent.

27 40 CFR 763, Subpart G requires personal zone monitoring with sample analysis by PEM to determine compliance with permissible exposure limits. Bulk sample analysis is not required.

28 40 CFR 763, Subpart G does not have different requirements for nonfriable asbestos.

29 Twenty-four of the 51 states have established threshold levels that trigger work practices, equipment controls, and other provisions that are lower than Federal standards. These states are: California, Colorado, Connecticut, Delaware, District of Columbia, Iowa, Kentucky, Maine, Massachusetts, Michigan, Minnesota, Nebraska, Nevada, New Hampshire, New Jersey, New York, North Dakota, Oklahoma, Oregon, Rhode Island, South Carolina, Utah, Vermont, and Wisconsin.

Four states apply work practices and equipment control requirements to all abatement projects; one state applies requirements to all demolitions, regardless of the volume of asbestos to be removed. One state applies requirements to all abatement jobs, with special (less stringent) requirements for jobs less than 20 square or linear feet.

Eight states have established their own thresholds. Two of these states apply work practices and engineering control requirements to all abatement projects greater than 3 square or linear feet. Three apply requirements to all jobs greater than 50 linear or 25 square feet, 50 linear or 32 square feet, and 30 linear or 18 square feet. Two states apply requirements to all abatement over 10 linear or 25 square feet and one state applies requirements to all jobs over 3 square or linear feet.

Four states apply special (less stringent) requirements for projects under the NESHAP threshold. Two states apply requirements to abatement projects more than 10 linear or 25 square feet but less than the NESHAP threshold; one state applies requirements to jobs more than 100 square or linear feet and less than the NESHAP threshold, one state applies requirements to all jobs more than 3 linear or square feet but less than the NESHAP threshold. One state applies practices to projects under the NESHAP threshold undertaken in residential buildings and other buildings that are not commercial or publicly owned buildings. One state applies the NESHAP threshold, but does not exempt apartments of 4 units or less.

30 Twenty-three of 51 states specifically require HEPA filters on negative pressure enclosures. These states are: Alabama, California, Colorado, Connecticut, Illinois, Kansas, Maine, Maryland, Massachusetts, Minnesota, Nebraska, Nevada, New Hampshire, New Jersey, New York, North Carolina, Oklahoma, Oregon, Rhode Island, South Carolina, Utah, Vermont, and Washington.

Many of these regulations require that the filtered air be exhausted to the outside where possible and not near any building intakes.. Where that is not possible, some states require daily sampling to confirm that fiber levels are not over 0.1 f//cc or continuous monitoring on a chart recorder. Some states specify that new filters must be used for each job and nearly all specify that the used filters must be disposed of as asbestos waste. One state (Minnesota) requires the filtration system to be equipped with a calibrated pressure guage, an automatic shutdown mechanism or an audible alarm in the event of a malfunction, and a built in mechanism to ensure the system will not operate unless it is positioned correctly. Most require that HEPA filtered exhaust ventilation operate continuously from the beginning of the project until clearance air sampling is approved.

31 Thirteen (13) of 51 states specifically address the use of wetting agents. These states are: Alabama, Colorado, Connecticut, Delaware, Illinois, Kansas, Maryland, Massachusetts, Nebraska, New Jersey, New York, North Carolina and Oklahoma. Three of these states specify that the wetting agent shall consist of 50 percent polyoxethylene ether and 50 percent of polyoxyethlene polyglycol ester or equivalent and shall be mixed with water to provide a concentration of one ounce surfactant to 5 gallons of water or as directed by the manufacturer. The other states require that the wetting agent be effective, be pretested for effectiveness, or that it be nontoxic.

32 No (zero) of the 51 states address viewing ports in the abatement enclosure.

33 Thirty eight of the 51 states have notification requirements in addition to or more stringent than the current NESHAP. The states that do not are: Alaska, Arkansas, Florida, Hawaii, Idaho, Kentucky, Louisiana, Mississippi, Montana, New Mexico, Pennsylvania, Wisconsin, and Wyoming. Typical notification requirements allow only 10 days notification (no 20 days for renovations), require local notification, require additional notification such as verification of a waste disposal site, notice of changes in information, and/or more information regarding the project, or apply to more jobs because of the different state threshold.

34 Only four (4) of the 51 states have not promulgated specific training requirements. The fours that do not have training requirements are: Idaho, Montana, Pennsylvania, and Wyoming. Nearly all states require the contractor to be registered with the state, liscensed as a specialty contractor, or liscensed as a building contractor. The contractor generally is required to be certified, although instructional training may or may not be required. Annual certification is required in most cases for supervisor and workers, inspectors, project designers, project monitors, and consultants. In addition to requirements based on age, education, and/or experience (these requirements vary widely), certification requires an initial training course and an annual 1 day refresher course (1/2 day for inspectors. Many states have specific requirements for the trainers and the training courses as well. Typically, supervisors require a 4 day course, workers (3 days), inspectors (3 days), planners (3 days and 2 days of management courses), and designers (3 days).

35 Five (5) of 51 states appear to have specific regulations for bulk sampling that supplement AHERA requirements. These requirements have been established in conjunction with state survey/inspection programs for school and nonschool buildings. The states are: Illinois, Massachusetts, Rhode Island, Virginia, and Vermont. The protocols differ from AHERA requirements in the number of samples taken (per square foot) and the sampling points (inside, outside), and laboratory quality assurance requirements.

36 Twenty-two (22) of the 51 states extend AHERA provisions for schools to require clearance air monitoring for nonschool abatement projects. These states are: Alabama, Colorado, Connecticut, Delaware, Kansas, Kentucky, Maine, Maryland, Massachusetts, Michigan, Minnesota, Nebraska, Nevada, New Hampshire, New Jersey, New York, North Carolina, Oklahoma, Oregon, Rhode Island, South Carolina and Vermont. California and Illinois include provisions for clearance monitoring that are applicable only to abatement jobs in schools.

The general steps for cleanup prior to monitoring are similar. Cleanup is performed using HEPA vacuums followed by wet methods (amended water may be required) for all surfaces until they are free of all visible residue. A second cleaning may be required 24 hours later. The contractor (or State personnel) perform a visual inspection; the cleaning sequence must be repeated until the area passes inspection. Porous surfaces that have been stripped to asbestos containing material may require a coating of an encapsulating agent. Prior to monitoring, floors, ceilings, and walls are blown with a leaf blower or stationary fans; some states include specifications for this equipment. Afterwards, air samples are taken. Depending on the state, all samples (or the average of all samples) can not exceed a concentration of 0.005 fibers over 5 microns/cc of air (8- hour TWA) or 0.01 f/cc by TEM or PCM. Three states were identified that require 0.05 f/cc. In nearly all states, an independent, certified professional must conduct the monitoring.

37 Six (6) of 51 states have survey/inspection programs and or maintenance provisions. Two states require maintenance. Massachusetts requires all buildings, including plants and utilities, to maintain asbestos insulation or covering on pipes or similar equipment to be maintained in good repair and free from defects which may permit dust release. Oregon requires all external surfaces in any place of employment to be maintained free of accumulation of asbestos fibers. --- other states have instituted inspection programs for public and/or commercial buildings. While the scope of these programs vary, they essentially require an inspection; sampling for friable asbestos; repair, replacement, removal, enclosure, or encapsulation of the asbestos; and maintenance until the asbestos is removed. (Note: more states have one-time inspection programs and will be added this week).

38 The District of Columbia assumes that all asbestos is friable; Connecticut applies different clearance monitoring levels for friable and nonfriable asbestos. No (zero) states were identified that apply special work practices and engineering controls to nonfriable asbestos, although disposal practices may differ in that they are less stringent compared to provisions for friable asbestos.

39 Seven (7) of 51 states include asbestos specific provisions for wastewater generated during asbestos abatements. These states are: Colorado, Illinois (school jobs only), Massachusetts, Nebraska, New Jersey, New York, and North Carolina. Three of the states require that shower water be filtered through a system with a least 5 micron particle size collection capability and then be discharged to a sanitary sewer; two of these states specify that the filter must be treated as asbestos waste. One state includes has a general standard that wastewater must be filtered by best available technology prior to discharge and does not differentiate between shower water and runoff from wetting during the abatement job. One state requires that all free water (except shower water) be combined with waste or HEPA filtered and disposed of in a sanitary sewer and another state specified that all free water in the contaminated area be retrieved and added to waste or placed in separate leak-tight drums. One state specifies that water shall not be used in amounts to cause runoff or leakage.

ATTACHMENT 1. DESCRIPTION OF REGULATORY ALTERNATIVES

THRESHOLD. This alternative would delete the threshold for determining applicability of work practices.

HEPA FILTERS. This alternative would require negative pressure/HEPA filters for all removals.

WETTING AGENTS. This alternative would require the use of wetting agents.

VIEWING PORTS. This alternative would require viewing ports in abatement enclosures.

NOTIFICATION. This alternative would add procedures that allow EPA to identify nonnotifiers.

TRAINING. This alternative would require training of asbestos inspectors, abatement workers and supervisors, and building owners.

BULK SAMPLING. This alternative would specify a protocol for collecting bulk samples for analysis.

ADEQUATE REMOVAL. This alternative would define "adequate removal".

MAINTENANCE. This alternative would regulate materials that fall off facility components due to lack of maintenance or require preventive maintenance on facility components.

NONFRIABLE. This alternative would revise the requirements for nonfriable materials.

RUNOFF. This alternative would regulate run-off from wetting and shower water.

TABLE 2A. COMPARISON OF STATE REGULATIONS AND ALTERNATIVES FOR ASBESTOS DEMOLITION AND RENOVATION

REGULATORY BASELINE	REGULATORY ALTERNATIVES										
	THRESH-HOLD	HEPA FILTERS	WETTING AGENTS	VIEWING PORTS	NOTIFI-CATION	TRAIN-ING	BULK SAMPLING	ADEQUATE REMOVAL	MAINTE-NANCE	NON-FRIABLE	RUN-OFF
Alabama	NO	YES[1]	YES[2]	NO	YES[3]	YES[4]	NO	YES[5]	NO	NO	NO
Alaska	NO	NO	NO	NO	NO	YES[6]	NO	NO	NO	NO	NO
Arizona	NO	NO	NO	NO	YES[7]	YES[8]	NO	NO	NO	NO	NO
Arkansas	NO	NO	NO	NO	NO	YES[9]	NO	NO	NO	NO	NO
California	YES[10]	YES[11]	NO	NO	YES[12]	YES[13]	NO	YES[14]	NO	NO	NO
Colorado	YES[15]	YES[16]	YES[17]	NO	YES[18]	YES[19]	NO	YES[20]	NO	NO	NO
Connecticut	YES[21]	YES[22]	YES[23]	NO	YES[24]	YES[25]	NO	YES[26]	NO	YES[27]	YES[28]
Delaware	YES[29]	NO	YES[30]	NO	YES[31]	YES[32]	NO	YES[33]	NO	NO	NO
D. Columbia	YES[34]	NO	NO	NO	YES[35]	YES[36]	NO	NO	NO	YES[37]	NO
Florida	YES[38]	NO	NO	NO	NO	YES[39]	NO	NO	YES[40]	NO	NO
Georgia	NO	NO	NO	NO	YES[41]	YES[42]	NO	NO	NO	NO	NO
Hawaii	NO	NO	NO	NO	NO	YES[43]	NO	NO	NO	NO	NO
Idaho	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Illinois	NO	YES[44]	YES[45]	NO	YES[46]	YES[47]	YES[48]	YES[49]	NO	NO	YES[50]
Indiana	NO	NO	NO	NO	YES[51]	YES[52]	NO	NO	NO	NO	NO

REGULATORY BASELINE	REGULATORY ALTERNATIVES										
	THRESH-HOLD	HEPA FILTERS	WETTING AGENTS	VIEWING PORTS	NOTIFI-CATION	TRAIN-ING	BULK SAMPLING	ADEQUATE REMOVAL	MAINTE-NANCE	NON-FRIABLE	RUN-OFF
Iowa	YES[53]	NO	NO	NO	YES[54]	YES[55]	NO	NO	NO	NO	NO
Kansas	NO	YES[56]	YES[57]	NO	YES[58]	YES[59]	NO	YES[60]	NO	NO	NO
Kentucky	YES[61]	NO	NO	NO	NO	YES[62]	NO	YES[63]	YES[64]	NO	NO
Louisiana	NO	NO	NO	NO	NO	YES[65]	NO	NO	YES[66]	NO	NO
Maine	YES[67]	YES[68]	NO	NO	YES[69]	YES[70]	NO	YES[71]	YES[72]	NO	NO
Maryland	NO	YES[73]	YES[74]	NO	YES[75]	YES[76]	NO	YES[77]	NO	NO	NO
Massachusetts	YES[78]	YES[79]	YES[80]	NO	YES[81]	YES[82]	YES[83]	YES[84]	YES[85]	NO	YES[86]
Michigan	YES[87]	NO	NO	NO	YES[88]	YES[89]	NO	YES[90]	NO	NO	NO
Minnesota	YES[91]	YES[92]	NO	NO	YES[93]	YES[94]	NO	YES[95]	NO	NO	NO
Mississippi	NO	NO	NO	NO	NO	YES[96]	NO	NO	NO	NO	NO
Missouri	NO	NO	NO	NO	YES[97]	YES[98]	NO	NO	YES[99]	NO	NO
Montana	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Nebraska	YES[100]	YES[101]	YES[102]	NO	YES[103]	YES[104]	NO	YES[105]	NO	NO	YES[106]
Nevada	YES[107]	YES[108]	NO	NO	YES[109]	YES[110]	NO	YES[111]	NO	NO	NO
New Hampshire	YES[112]	YES[113]	NO	NO	YES[114]	YES[115]	NO	YES[116]	YES[117]	NO	NO
New Jersey	YES[118]	YES[119]	YES[120]	NO	YES[121]	YES[122]	NO	YES[123]	NO	NO	YES[124]

REGULATORY BASELINE	REGULATORY ALTERNATIVES										
	THRESH-HOLD	HEPA FILTERS	WETTING AGENTS	VIEWING PORTS	NOTIFI-CATION	TRAIN-ING	BULK SAMPLING	ADEQUATE REMOVAL	MAINTE-NANCE	NON-FRIABLE	RUN-OFF
New Mexico	NO	NO	NO	NO	NO	YES[125]	NO	NO	NO	NO	NO
New York	YES[126]	YES[127]	YES[128]	NO	YES[129]	YES[130]	NO	YES[131]	NO	NO	YES[132]
N. Carolina	NO	YES[133]	YES[134]	NO	YES[135]	YES[136]	NO	YES[137]	NO	NO	YES[138]
North Dakota	YES[139]	NO	NO	NO	YES[140]	YES[141]	NO	NO	NO	NO	NO
Ohio	NO	NO	NO	NO	YES[142]	YES[143]	NO	NO	NO	NO	NO
Oklahoma	YES[144]	YES[145]	YES[146]	NO	YES[147]	YES[148]	NO	YES[149]	NO	NO	NO
Oregon	YES[150]	YES[151]	NO	NO	YES[152]	YES[153]	NO	YES[154]	YES[155]	NO	NO
Pennsylvania	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Rhode Island	YES[156]	YES[157]	NO	NO	YES[158]	YES[159]	YES[160]	YES[161]	YES[162]	NO	NO
S. Carolina	YES[163]	YES[164]	NO	NO	YES[165]	YES[166]	NO	YES[167]	NO	NO	NO
South Dakota	NO	NO	NO	NO	YES[168]	YES[169]	NO	NO	NO	NO	NO
Tennessee	NO	NO	NO	NO	YES[170]	YES[171]	NO	NO	NO	NO	NO
Texas	NO	NO	NO	NO	YES[172]	YES[173]	NO	NO	NO	NO	NO
Utah	YES[174]	YES[175]	NO	NO	YES[176]	YES[177]	NO	NO	NO	NO	NO
Virginia	NO	NO	NO	NO	YES[178]	YES[179]	YES[180]	NO	NO	NO	NO
Vermont	YES[181]	YES[182]	NO	NO	YES[183]	YES[184]	YES[185]	YES[186]	YES[187]	NO	NO

REGULATORY BASELINE	REGULATORY ALTERNATIVES THRESH-HOLD	HEPA FILTERS	WETTING AGENTS	VIEWING PORTS	NOTIFI-CATION	TRAIN-ING	BULK SAMPLING	ADEQUATE REMOVAL	MAINTE-NANCE	NON-FRIABLE	RUN-OFF
Washington	NO	YES[188]	NO	NO	YES[189]	YES[190]	NO	NO	NO	NO	NO
West Virginia	NO	NO	NO	NO	YES[191]	YES[192]	NO	NO	NO	NO	NO
Wisconsin	YES[193]	NO	NO	NO	NO	YES[194]	NO	NO	NO	NO	NO
Wyoming	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

CODE: "YES" means the State rule contains a provision similar to or equivalent to the regulatory alternative. "NO" means the rule is similar to or equivalent to existing Federal rules.

1 Alabama has additional guidelines for asbestos abatements conducted in public buildings; the guidelines do not apply to the private sector. The asbestos specification guidelines requires that HEPA filters be equipped with filtration equipment in compliance with ANSI 29.2-79, local exhaust ventilation. No air movement system or air filtering equipment should discharge unfiltered air outside the work area Section (2.2.1.1). The contractor also must submit a manufacturer's certification that vacuums, negative air pressure equipment, and other local exhaust ventilation equipment conform to ANSI 29.2-79 (Section 1.5.1.7).

2 Asbestos specification guidelines guidelines requires that after site preparation, the asbestos is to be sprayed with amended water and sprayed repeatedly during the work process to maintain a wet condition (Section 3.2.2). The wetting agent consist of 50 percent polyoxyethylene ether and 50 percent of polyoxyethlyene polyglycol ester, or equivalent, and shall be mixed with water to provide a concentration of one ounce surfactant to 5 gallons of water or as directed by the manufacturer (Section 2.1.4).

3 Asbestos specification guidelines requires notification of proposed abatement jobs to the applicable air pollution control agency, at least 10 days before the work begins, with a copy to the building owner, in lieu of notification to EPA (Section 1.5).

4 Rule 14-3 of the Alabama Building Commission requires training and certification for public sector abatement projects. Workers must be instructed on work procedures and protective measures and all asbestos removal personnel must be State accredited. Workers need identity cards establishing training completion. Abatement contractors, subcontractors, architects, and engineers must be approved annually by the Commission; to be approved, initial applicants must have attended an approved seminar and completed the examination within the past six months. Renewal applicants must have attended the approved seminar within the past six months or have completed at least two abatement projects during the last year under the jurisdiction of the Building Commission. Section 1.5.1.4 of the asbestos specification guidelines also requires that the contractor submit documentation to the architect/engineer prior to beginning the job indicating that each employee has had instruction on work procedures and protective measures.

5 Sections 3.5.6 and 3.5.7 of the asbestos guidance specifications require testing for initial clearance and reoccupancy clearance for public sector abatement jobs. After completion of the job, work areas and all other contaminated and cleaned areas must meet 0.1 or less f/cc. Areas that do not meet this limit must be recleaned. After initial clearance, the architect/engineer performs a visual inspection and may require further cleaning. After the reoccupancy inspection, the architect/engineer contacts the State Authority (Safe State) to request an inspection and reoccupancy testing. Reoccupancy is approved when air levels reach 0.005 f/cc or less. Failure to achieve this level requires further cleaning by the contractor. Specific work practices for the cleaning (based on wet-cleaning or HEPA vacuums) are provided.

6 Article 8 of the Administrative Code requires certification of the contractor, supervisor, monitor, and employees. Abatement contractors must submit a plan for the certification of its employees; the plan must be approved before beginning the abatement job. The contractor also must certify that each employee working on the project is properly trained At least 32 hours of instruction and 12 hours of hands on training is required to obtain certification; certification is for each 3-year period. Minimum requirements for instructors (5 day course, 2 years abatement experience, and 5 years as a safety professional) and training courses and special requirements for AHERA abatement workers also are established. Training must be provided at the time of initial assignment and annually after completion of training course. Laboratory workers must take NIOSH course or equivalent for sampling and evaluating airborne asbestos (.05.045 of Construction Code, Appendix A).

7 Sections 20.06 and 20.07 of Arizona Revised Statute requires specific project notification form to be filed with county, State, and Regional offices at least 20 days before project begins. After completion of project, a notification form for waste disposal must be filed (Sections 20.06, 20.07, and 20.08 of Arizona Revised Statute).

8 License from Arizona Registrar of Contractors required for all contractors (Arizona Revised Statute 32-1151). The "responsible managing employee (i.e., supervisor) must be certified; certification requires 4 years practical or management trade experience or 2 years experience and 2 years technical training in accredited college or in a manufacturer accredited training program. No other training requirements for other workers or employees in asbestos industry.

9 Arkansas requires annual licensing of asbestos abatement contractors; contractors must have at least one year experience in abatement to qualify. All workers and supervisors must be certified. Training is required to obtain license or certification. Courses for workers must entail at least 24 hours of instruction; contractors and supervisor courses must consist of at least 32 hours of instruction. Both courses must include at least 6 hours of hands-on training; annual refresher courses also are required to renew certifications and licensing. "Other interested persons (e.g., consultants and industrial hygiene firms) also must be licensed (Commission Regulations for Asbestos Contractor Licensing).

10 Special operating and procedural requirements apply to residential and other buildings (not commercial or public buildings) for demolition and renovation activities of less than 260 linear or 160 square feet (Rule 1403). Building owners, employers, and abatement contractors must make a good-faith effort to determine if asbestos is present before work is begun. Annual registration required for abatement contractors for work involving 100 square feet or more of surface area (California Labor Code, Section 6501.5 - 6505.5). Safety conference required before commencement of job regardless of amount of asbestos to be handled (Occupational Safety and Health Regulations, Title 8, Article 2.5). Establishes work procedures for demolition, renovation, and removal projects larger than NESHAP cutoff.

11 HEPA filters are used extensively to meet the 0.01 f/cc exposure level (add citation). South Coast Air Quality District specifies requirements for abatement procedures, including HEPA filters (Rule 1403).

12 Notification requirements applicable for asbestos related work of 100 square feet or more of surface area; changes must be reported to OSHA at or before time or change and if oral notification of change is made, must be confirmed in writing within 24 hours after the change (Article 2.5, Section 341.9(a)). For public and commercial buildings and apartments with more than 10 units constructed before 1979 where owner knows building contains asbestos, building owner must provide specified written notice to employees, tenants and other building occupants (Health and Safety Code, Chapter 1502). Contractor who inspects building for asbestos or for remedial action must notify if person performing corrective work has any financial interest (Article 2.5, Section 21.12).

13 Requires certification and training for abatement workers, supervisors, and operation and maintenance workers. Classroom instruction or hands on training also required for solid waste facility personnel (Chapter 30, Article 18).

14 Any primary or secondary school building in which asbestos abatement work has been performed must not be reoccupied until air monitoring shows the asbestos concentration does not exceed 0.01 f/cc; one month after reoccupancy, remonitoring is required to ensure compliance with the 0.01 standard (AB 2040(c)).

15 Permit, work practice/equipment control, and notification requirements apply to abatement jobs greater than 50 linear feet on pipes or 32 square feet on other surfaces. Requirements do not apply to single family dwellings if project conducted by resident. Minor jobs require dust control permit and must comply with general abatement standards that require containment barriers.

16 Negative pressure air filtration units equipped with HEPA filters must be operated continuously from time of containment barrier construction through time of acceptable final air clearance monitoring are obtained. Units must exhaust filtered air to outside when length of exhaust duct required to do so does not overburden the negative air units. If air exhausted outside, samples must be taken daily and analyzed by PCM or equivalent method to ensure compliance with Maximum allowable asbestos level (0.01 f/cc) and that there is no breech in the filtering system. (Colorado Regulation No. 8, Section III(c)(2)(a). Exceptions are if the use of a filter creates a fire or explosion hazard (wet collectors designed to operate with a unit contacting energy of at least 40 inches of water gauge pressure may be used as a substitute and if equivalency of other filtering equipment can be demonstrated (Section III(r)).

17 Wetting agents shall be added to water and be used to soak asbestos containing material before removal is attempted. Only airless sprayers can be used to apply amended water or encapsulants to asbestos containing material. When wetting agents are applied to amosite asbestos, the amosite must be soaked as much as possible and be bagged for disposal when wet. (Rule No. 8, Sections III(g) and (i)).

18 Permit and notification required for projects where asbestos material exceeds 50 linear feet on pipes or 32 square feet on other surfaces. New permits must be obtained for projects lasting more than one year. Permit must be modified to reflect any changes and must be submitted at least 10 days before start of project. Notification of emergency work can be by telephone; written notification must follow the next day. Contractor or building owner also must notify if asbestos found unexpectedly. Building owner or contractor also must notify for demolition of building declared structurally unsound and in danger of imminent collapse (Asbestos Renovation and Demolition Air Pollution Control Requirements).

19 Contractor must be certified to perform jobs involving over 50 linear feet or 32 square feet. Contractor must employ at least one certified trained supervisor who is on site at all times. Training is required for supervisors (4 day course) and workers (3 day course). Training also required for school inspectors (3-day course with 4 hours of hand on training), management planners (2 day course), project designers (3 day course), and workers, including custodial and maintenance employees (3 day course). Annual 1 day refresher course required for school abatement workers, school supervisors, school project designer, and nonschool supervisors (Emergency Rule Revisions to Air Quality Control Commission Regulation No. 8).

20 Regulations apply requirements for clearing abatement projects in nonschool buildings similar to AHERA provisions. Where amount of asbestos in job is more than 50 linear feet on pipes or 32 square feet on other surfaces, visual inspection to determine that all dust and debris has been removed is followed by air sampling with analysis by TEM or PCM; provisions for determining compliance also are given. (Regulation No. 8, Section III.7).

21 Procedures for asbestos abatement projects apply to all jobs regardless of size except projects involving exterior nonfriable materials which may become friable as a result of abatement; these jobs must comply with EPA and OSHA standards. Also requires different threshold for notification and for clearance.

22 Negative pressure ventilation units with HEPA filtration shall be provided in sufficient number to allow at least one workplace air change every 15 minutes; filtered air should be exhausted to areas outside the building which are not near any intake for the building ventilation systems (Standards for Asbestos Abatement, Section 19a332a-5(8)).

23 Amended water must be used for cleanups; all waste must be adequately wetted with an amended water solution (Standards for Asbestos Abatement, Section 19a332a-5(7) and (10)).

24 Contractor must notify State for projects involving more than 10 linear feet or more than 25 square feet of material (Section 19a-332a-3).

25 Abatement contractors and consultants (including inspectors, management planners, project designers, and project monitors) must be licensed and renewed annually. Certification required for consultant license (1 day training). Training required for site supervisors, project designers and project monitors (5-days), workers (4 days), inspectors (3 days), management planners (3 days plus 2 day management course) (Licensure and Training Requirements for Persons Engaged in Asbestos Abatement and Asbestos Consultation Services, Section 19a-332-18 - 22). Certification also required for operator of solid waste disposal facility (Section 22a-209-6(c).

26 Post abatement reoccupancy criteria same as AHERA requirements for schools. Sample collection and analysis not required for abatements involving only nonfriable asbestos in amounts less than 260 linear or 160 square feet(except for schools) or performed on exterior of facility (Section 19a-332a-12(b)).

27 Reoccupancy criteria differ for friable and nonfriable materials.

28 Wastewater generated during asbestos abatements shall be filtered by the best available technology prior to discharge (Section 19a-332-5(10)).

29 Asbestos projects less than 160 square feet or 260 linear feet must take the following precautions: (1) wetting any asbestos (except for encapsulation), (2) sealing work area and using appropriate work practices, (3) leave no visible residue after completing project, (4) sealing waste in an appropriate container, and (5) disposing of waste at an approved site or landfill (Regulation 21).

30 Wet asbestos material to be stripped or removed with water solution containing a surfactant that will adequately wet the material (Regulation 21).

31 Notify Solid Waste Authority 24 hours in advance of disposal with the anticipated amount of waste to be disposed (unwritten policy).

32 Contractors must be certified and complete approved training program; certification must be renewed annually. Workers and supervisors also must be certified and trained. Amount of training not specified. (Section 7803).

33 For buildings and structures to be demolished, after removing asbestos material, clean work area until no residue of asbestos material is visible. For any project exceeding NESHAP threshold, first preclean and visually inspect. Use forced air equipment (leaf blower, fan) to direct air against ceilings, walls, etc. Air sample by PCM or TEM to determine that concentration of fibers equal to or longer than 5 microns is less than 0.01 f/cc (8-our TWA). PCM analysis considers all fibers to be asbestos. If concentration is not less than 0.01, reclean with HEPA vacuums and wet wipe methods and resample (Regulation 21).

34 Primarily adopts NESHAP but applies it to all projects over 30 linear or 18 square feet (D.C.R.R., Title 20, chapter 8, Section 800.1(c)).

35 Contractors must submit written notification to Department of Consumer Affairs and receive project approval prior to commencing a renovation or demolition project. (D.C.R.R., Title 20, Chapter 8, Section 800.1(e) and (f)). Also, any person doing demolition, alteration, or repair of any building must indicate whether there is asbestos in the building. If so, notification must be given to the D.C. Housing and Environmental Regulation Administration. Before building permits are issued, owner must certify that all asbestos has been removed or that the project will not disturb existing asbestos (BLRA Administrative Order 89-1).

36 Requires a person who handles any material containing asbestos to be licensed; currently there is no asbestos licensing agency or training certification rules (Asbestos Licensing and Control Act of 1990 pending Congressional approval).

37 Does not define asbestos; creates a rebuttable presumption that all asbestos is friable (DCRR, Title 20, chapter 8, Section 800(a) and (d)).

38 Except for schools and state owned buildings, repairs, removal, encapsulation or enclosure of less than 12 square or linear feet performed by full time employees of building owner or operator and in an area where access is restricted to authorized personnel are exempt from contractor/consultant license requirements (Florida Statutes, HB 1473, 455.302(4)(a)).

39 Contractors must be licensed and certified; license must be renewed every 2 years (6 hour review course); certification requires 4 course (3 days in surveys and mechanical systems, 2 days of management planning, 3 days in respiratory protection, and 4 days project management/supervision). Consultants who are not licensed architects and engineers must be licensed (renewed every 2 years with 2 day continuing education course) and certified; training same as for contractors. Monitors (4 days training), management planners (2 days training), and surveyors (3 days training) must be licensed or working under trained and licensed consultant; 1 day continuing education annually required for license/certification. Workers require 3 days training and 1 day continuing education annually. Supervisors require 4 days training with 1 day continuing education annually (Florida Statutes 455.302 and 303; HB 1473, 455.305, 308, 309). Certified roofers with approved training may remove AC bituminous resinous roofing systems (455.302(3)(3)(d)).

40 Each State agency must survey asbestos containing material in each public building for which it is responsible; the survey must be conducted by a licensed asbestos consultant (Florida Statutes 255.552). Each State Agency must initiate operation and maintenance plan that remains in effect until all material removed (Florida Statutes 255.557(1)).

41 Contractor must notify State at least 7 days before beginning project and must submit notice of project completion that includes asbestos disposal manifest form. Additional notification is required if more asbestos containing materials are found during the removal (Chapter 391-3-14(2)).

42 Contractors and foremen must be licensed; 32 hours of training required (Chapter 52-4-01(a)).

43 Contractors must be licensed; training requirement is a 4 EPA day course; 16 hour refresher course for license renewal. Supervisors do not require license, but training is the same as for contractors. Workers (asbestos handlers) must be certified (Act 157, Section 2) and trained (3 day course with 16 hour refresher course or 8 hours if received training in second year of 2 year license requirement for contractor. License requirements do not apply to maintenance, repair, or removal of asbestos pipe or sheets, vinyl asbestos floor materials, or asbestos-bituminous or resinous material operations. (Chapter 444, Hawaii Revised Statutes).

44 For school projects, negative air pressure systems must be operated in accordance with "Specifications for the Use of Negative Pressure Systems for Asbestos Abatement: Guidance for Controlling Friable Asbestos-Containing Materials in Buildings (EPA 560/5-85-024) (Section 855.120). Also, "negative pressure system is defined as "a portable local exhaust system equipped with HEPA filtration (Section 855.20).

45 For school projects, adhesive for sealing joints in containment barrier must be capable of adhering under wet and dry conditions, including during the use of amended water. The surfactant must be a product that is nontoxic, noncarcinogenic, and is not an eye, nose, or skin irritant (Title 77, Chapter I, Subchapter p, Section 855.120).

46 Contractors for school abatement jobs not covered by NESHAP must submit notification. School projects over 13 square or linear feet require notification to School Board or building owner and Department of Public Heath 2 week before beginning job (Title 77, Chapter 1, Subchapter p, Section 855.60).

47 Training and certification required for school abatement workers, abatement supervisors, inspectors, management planners, and project designers.

48 Establishes procedures for bulk sampling during school inspections including: (1) collect minimum of 3 samples for each homogeneous sampling area of less than 1,000 square feet; for areas 1,000 - 5,000 square feet, collect minimum of 5 samples; for larger areas, collect 7 samples, (2) do not sample nonfriable pipe and boiler insulation; assume it is asbestos-containing material; collect at least 1 sample from each homogeneous area of patched thermal insulation that is not assumed to be asbestos containing material if the section is less than 6 linear or square feet, (3) take precautions such as wearing respirator, seal sample with clear, nonflammable encapsulant, cleanup any visible materials by wet methods, dispose of contaminated materials in 6 mil plastic bags. Sampling procedures include (1) light wetting, (2) gently cut and remove small core penetrating all layers including any paint or protective coating; wet wipe any reusable instrument before reuse, (3) place sample in whirl-pak plastic bag; seal bag and wipe exterior with damp cloth; label each bag with a sample ID number, (4) seal samples in second plastic bag.

49 For school cleanup, negative pressure system must remain in continuous operation. All visible asbestos material and debris must be removed and containerized. All surfaces must be wet-cleaned. The cleaned outer layer of plastic sheeting is removed; windows, doors, HVAC vents and other openings remain sealed. Second cleaning begins 24 hours after first cleaning to allow fibers to settle. All objects and surfaces are HEPA-vacuumed and wet-cleaned. Remaining plastic on walls and floors is removed; other openings remain sealed. Final cleaning starts 48 hours after second cleaning using wet methods and/or HEPA vacuums. Contractor inspects for visible residue by wiping surface with a dark cloth; if any residue is observed, it is assumed to be asbestos and the 48 hour settling period/cleaning cycle is repeated. Clearance air monitoring then is begun. Following completion of clearance air monitoring, remaining barriers and decontamination enclosure systems are removed and disposed of as asbestos waste. The entire area, including HVAC filter assembly and ductwork is wet cleaned or HEPA vacuumed; new filters in HVAC systems are then installed (Section 855.220 and .250) Air sampling professional must perform monitoring; sampling may not begin until 24 hours after completion of wet cleaning.

50 Shower enclosures for employees in school abatement jobs must be leak-free; shower water shall be drained, collected, and filtered through a system with at least 5.0 micron particle size collection capability. A system containing a series of several filters with progressively smaller pore sizes shall be used to avoid rapid clogging of the filtration system by large particles. Filtered water shall be discharged to a sanitary sewer (Section 855.140)

51 Contractor must file disposal notification form prior to waste disposal in addition to NESHAP demolition/renovation notification form (329 IAC 2-21).

52 Requirements for accreditation and training apply only to school projects. 4-day training required for supervisor and 3 days training for workers; 1-day refresher course required for both. Consultants and management planners must have 2 days training and project designers and inspectors, 3-days (326 IAC 18-1).

53 All abatements must meet Federal standards, regardless of size.

54 A 10 day advance notification to the Department of Labor Services is required for all asbestos abatement projects.

55 Abatement contractors require license (4 days training); workers and supervisors must be certified (3 days training for workers and 4 for supervisors). School inspectors (3 days), planners (3 days and 2 day management course), and designers (3 day course) require a license. Operation and maintenance workers must be trained as required by OSHA and receive 2 additional hours of awareness training).

56 HEPA filtered ventilation fans shall be installed in a manner that will continuously exhaust air from all locations in the work area. The fan shall be operated continuously throughout the duration of the project until at least 24 hours after the final cleanup action (KAR 28 50-9).

57 Any friable asbestos shall be wetted with a water solution containing an effective wetting agent (KAR 28-5-9).

58 Written application must be made to Bureau of Waste Management for approval of waste disposal at an approved disposal site (Section 650-3406).

59 Annual license required abatement contractors (KRS 65-530). Workers must have 18 hours training; supervisors must have 24 hours training and be certified (KAR 28-50-5). Certification not required for building owner's employees who perform abatement maintenance work.

60 Work practices on projects to be reoccupied requires cleaning of plastic sheeting, equipment and surfaces by HEPA vacuum and/or wet methods so they are free from all visible residue, except that if more than one layer of plastic sheeting has been used. Remove sheeting and dispose of in compliance with disposal requirements; use wet cleaning to remove any liquid or material that has leaked through additional layers of sheeting. After sheeting has been removed, clean all previously covered surfaces with HEAP vacuum or wet cleaning so they are free of all visible debris. The surfaces from which friable material has been removed must be covered with an effective sealing material before the final layer of sheeting covering the floors, walls, and nonmovable items is removed. A minimum of 24 hours must be allowed between application of the sealant and removal of the final layer of plastic sheeting. Within 24 hours of completing the cleanup, an airstream from a high speed leaf blower or equivalent shall be swept across all cleaned surfaces for no less than 5 minutes per 1000 feet of surface area. Airtight seals shall remain in place for at least 24 hours after completion of the blower.

61 Any abatement entity engaged in an abatement project, including emergency operations, not subject to NESHAP or state regulations must take reasonable precautions to prevent release of asbestos fibers, including construction of adequate barriers, wetting prior to removal, use of HEPA vacuums and wet cleaning to cleanup until there is no visible residue, and proper waste disposal methods.

62 Abatement contractor must be certified; supervisor must have approved training course (401 KAR 63:042, Section 5).

63 Following abatement, wall and floor sheeting shall be removed and containerized for disposal. A sequence of HEPA vacuuming and wet wiping all exposed surfaces shall be performed until no visible residue is observed in the work area. A minimum of 24 hours after wet wiping is required to ensure that sufficient drying has occurred. Clearance monitoring must be performed. At least 5 samples of air per work area or 1 per room is required; a sample volume of 3,000 liters of air must be used. Air samples must be obtained when air is artificially circulated. Barriers can not be dismantled or openings uncovered until final samples show total fiber concentrations less than or equal to 0.01 f/cc (401 KAR 63:042, Section 4).

64 All public buildings must be inspected for friable asbestos and be reinspected annually for nonfriable asbestos (KRS 56.062).

65 Contractors must be certified and all inspectors, management planners, project designers, supervisors, and workers for projects larger than 3 square or linear feet must be accredited. Training required only for school projects: inspectors (3 days), management planners (3 days plus 2 day management course), project designers (3 days), supervisors (4 days), workers (3 days), maintenance and custodial workers (14 hours plus 2 hours awareness training if work with asbestos or 2 hours awareness training if they do not) (LAC:III, Chapter 27, Appendix A).

66 State must inspect public buildings for friable and nonfriable asbestos and reinspect every 3 years (LAC:III.2707B).

67 Statute mandates promulgation of work practices and procedures for abatement projects involving more than 100 square feet of 100 linear feet of covered or coated pipe; no regulations currently in effect. For projects less than 100 square or linear feet, reasonable precautions must include work barriers, wetting, HEPA vacuums and wet cleaning for cleanup until there is no visible residue, and proper waste disposal (Chapter 12-A, Subsection 1280).

68 Negative pressure HEPA equipped ventilation units must be operated from the time the barrier construction has begun through the time that final clearance has been obtained (Asbestos Abatement Regulations, Chapter 136.9).

69 10 day notice required before beginning abatement project involving more than 100 square feet or 100 linear feet of covered or coated pipe (Chapter 12-A, Subsection 1273). Notification also required for individual, nonscheduled abatement projects at a facility involving the removal of less than 100 linear or square feet if cumulative amount of asbestos in one building or structure removed over the course of a year will exceed the limit. Project notification not required for residential buildings of 4 units or less. In emergency situations, necessitated by nonroutine equipment failure, notification may be waived but oral notification required within 1 working day and written notification required within 3 days of activity. 10 day notification also required for waste disposal to Bureau of Land Quality Control.

70 Contractor, workers, supervisors, evaluation specialists, consultants and industrial hygiene firms must be registered; training requirements not yet promulgated. (Chapter 12-A, Section 1274). Registration no required for residential buildings of 4 units or less (Interim Regulations, Section 1.6.2).

71 No visible residue or debris in work area after cleanup. For projects less than 100 linear or square feet, final clearance inspection can be done by an abatement supervisor. For larger projects, work area must be visually inspected and any final clearance air sampling done by an evaluation specialist (Chapter 136.9). No regulations for project monitoring currently in effect.

72 State-owned buildings must be surveyed and where necessary, abatement projects conducted by the Department of Administrative Services (1987 Laws, Chapter 71).

73 HEPA filters are required if a negative pressure enclosure is used. However, negative pressure enclosures may not be required in all cases; the State may approve alternative procedures on a case-by case basis and in licenses for specific types of asbestos projects if it is demonstrated that compliance is not practical or feasible or that the proposed alternative provides equivalent control (Code of Maryland, 26.11.21.06(E) and 26.11.21.11).

74 Wet asbestos to be stripped or removed with a solution containing 1 fluid ounce of surfactant mixed with 5 gallons of water. Use a surfactant containing 50 percent polyoxyethylene ester and 50 percent polyoxyethylene ether or equivalent surfactant approved by Department (Code of Maryland, 26:11:21.06(B)).

75 In addition to NESHAP notification, contractor must notify Department of Health and Mental Hygiene of the location of removal or encapsulation project and approximate amount of asbestos involved (Title 6, Subtitle 6, Subtitle 4, Section 6-414.1). Notification on encapsulation projects over NESHAP threshold must be made as soon as possible before project begins; all new licensees must send notification of first 2 projects at least 3 days before beginning projects (Code of Maryland, 26:11:21.03). Contractor also must submit copy of record or receipt showing disposal facility and date to Department of Health within 10 days of disposal (26:11:21:08).

76 Contractors must be licensed and each employee complete an approved training program (Section 6-409). Employee (including agents of the contractor such as consultants, hygienists, investigators, air monitors) must receive initial training (6 hours) and approved 4 hour annual review course (Code of Maryland, 26:11:21.13).

77 For building to be demolished, clean work area after removing asbestos material until no residue or asbestos material is visible. For other projects exceeding NESHAP threshold (after removing any asbestos materials and before removing any plastic barriers: (1) clean all surfaces using water and surfactant solution, (2) after surface has dried, vacuum any remaining dry residue with HEPA vacuum, and (3) repeat sequence of wet mopping and vacuuming until no residue is visible and measured airborne concentration of fibers longer than 5 microns is less than 0.1 f/cc (8-hr TWA).

Clearance air monitoring required for project over NESHAP threshold. At minimum, one sample is required for each room and one sample for each 50,000 cubic or 5,000 square feet of floor space, whichever measure results in more samples. Contractor must forward clearance air monitoring results to Department of Health within 24 hours of receipt of results and prior to removing barriers. Barriers can be removed as soon as clean air is achieved (Code of Maryland, 26:11:21:06(B)).

78 Regulations applicable to all abatement jobs; replacement of furnaces and boilers that are covered or coated with asbestos also are abatement jobs. Work practice requirements also apply to projects involving asbestos cement materials that are broken and to excavations involving the removal, cutting, and disposal of asbestos cement pipe (453 CMR 6.14).

79 Exhaust air shall be HEPA filtered before being discharged outside of the work area. Air filtration devices shall have used pre-filters removed and replaced with fresh filters prior to removal of the unit from an asbestos work area; if HEPA filters are not changed, the equipment shall be wrapped in plastic sheeting prior to removing it from the work area. Used HEPA filters and refilters must be disposed of as asbestos waste. In all cases where feasible, HEPA filtered exhaust air shall be discharged to the outside of the building; when air is discharged to the interior, the outflow shall be sampled and analyzed at least once per day per machine. If at any time fiber levels in the exhaust air exceed 0.01 f/cc, the work operation shall stop immediately and the unit be shut off and replaced or repaired before the operation is resumed (453 CMR 6.14).

80 Prior to removal, asbestos must be thoroughly wetted with water to which a surfactant has been added or with a substitute wetting solution suitable to reduce generation of dust (453 CMR 6.14).

81 Notification to Department of Environmental Quality Engineering required at least 20 days before the project regardless of the amount of asbestos involved (310 CMR 7.15) Contractors must notify the Department of Labor and Industries before beginning any job that involves more than 3 linear on pipes or ducts or 3 square feet of asbestos on structures other than pipes or ducts; 10 days required for notification (453 CMR 6.12).

82 Contractors must be licensed; requires 5 day training for contractor and supervisor with 1 day annual refresher course (453 CMR 610). Certification required for workers (4 days and 1 day annual refresher course), inspectors (3 days and 1/2 day refresher annual refresher course), management planners (3 days and 2 day management course with annual review course for contractors/supervisors), project designers (5 days) and project monitors (5 days). Operation and maintenance worker require 2 days training if engage in projects involving less than 3 square or linear feet or worker training (4 days) if more than 3 square or linear feet (453 CMR 6.01, 6.05, 6.07, 6.10).

83 Analysis must be performed by or under supervisor of analyst with approved training course in bulk sample identification and laboratory that shows evidence of proficiency rating in EPA bulk sampling quality assurance program (453 CMR 6.08). Laboratory must apply for certification in SEM or TEM after applicant demonstrates adequate training and submits copies of analytical protocols to be followed (453 CMR 6.08).

84 Following an abatement project, cleanup procedures using HEPA vacuums and/or wet cleaning shall be used to decontaminate all equipment, materials, and surfaces (barriers must remain in place and ventilation systems in operation). An inch of soil shall be removed from dirt floors; all cleanup materials must be disposed of as asbestos waste. Project is satisfactorily completed when work area is free of visible debris and area meets release criteria of clearance air monitoring. Projects under 3 square or linear feet and projects where glove bag is used as the sole removal or repair method are exempt from clearance air monitoring (453 CMR 6.14).

Clearance monitoring requires at least 1 sample per 1000 square feet up to 5000 square feet plus one sample for each additional 5000 square feet or 1 sample per room, whichever is greater. Collection must be done by certified project monitor and analysis by certified laboratory. Clearance is achieved when air concentration does not exceed 0.01 f/cc (453 CMR 6.14).

85 All building owners are required to maintain asbestos insulation or covering on pipe, boilers or furnaces in good repair and free from defects such as holes, cracks, tears or looseness which may permit the release of asbestos dust. This also applies to industrial plants and utilities; any repairs required are subject to approval of the Department of Health (105 CMR 410.353(A)-(G)).

If abatement is the primary purpose of any operation and maintenance job, it must be performed by licensed contractor. If project involves less than 3 square or linear feet and abatement is not the principal purpose of the project, workers must have 2 days training (453 CMR 61.03). Workers who perform spot repairs must receive personal protection equipment and follow minimum requirements including: (1) airtight barriers and excluding unauthorized persons from work air, (2) use of glovebags, (3) wetting, (4) enclosure or encapsulation of asbestos, (5) HEPA vacuuming or wet cleaning for decontamination, and (6) proper waste disposal (453 CMR 6.14).

86 Water should not be applied in amounts that will cause run-off or leakage from the project area (453 CMR 6.14).

87 Regulations specify procedures for projects involving more than 25 linear or 50 square feet for employee health and safety (which require any other devices, clothing, equipment, and practices required by other state or federal law pertaining to the health and safety aspects of demolition, renovation, and encapsulation: see P.A. No. 147, Section 60(a)(5)) and clearance monitoring.

88 10 day advance notification required before beginning any project exceeding 5 linear or 6 square feet and for renovation/demolition; waiver of notice allowed in emergency situation but telephone notification to Department of Public Health required within 48 hours of starting project (P.A. 135 of A86, Section 220).

89 Contractor must be licensed. Training required for all response actions except small scale or short duration operations (4 days training for contractors and supervisors, 3 days for workers), inspectors (3 day training and 1/2 day annual refresher course), management planners (3 days training plus 2 day management course and 1 day annual refresher course), project designers (3 days training or 4 day contractor/supervisor course and 1 day annual refresher course). Accreditation required for inspectors, management planners, and project designers.

90 Post abatement air monitoring required for all projects involving over 25 linear or 50 square feet, including glove bag operations. Clearance monitoring shall not exceed 0.05 fibers greater than 5 micrometers in length. Clearance monitoring for glove bag operations may be waived if neutral third party has conducted breathing zone monitoring throughout project and all results are below clearance level of 0.05 f/cc (P.A. No. 147, Section 60(c)).

91 Requires specific work practices for the demolition of any building or structure, except single family and two family dwellings (Rule 7005.1580).

92 A ventilation system must be installed to create negative pressure within the enclosure; the system must be equipped with HEPA filtration. The system must be operated continuously for the duration of the project until final cleanup is completed. Whenever feasible, the system must be positioned to exhaust filtered air to the outside of the building. Whenever a HEPA-filtered ventilation system is exhausted to the indoors, asbestos air concentrations must be monitored daily (Rule 7005.1616, Subpart 4); indoor air concentrations can not exceed 0.01 f/cc by PCM (Rule 7005.1616, Subpart 2). At minimum, the HEPA filter system must be equipped with: (1) a calibrated pressure gauge, (2) a built in mechanism for automatic shutdown in the event of a breach in the filter or an audible alarm if the system shuts down and (3) a built in mechanism to ensure the ventilation system will not operated unless it is positioned correctly (Rule 7005.1616, Subpart 4)

93 Notification to Department of Health is required 5 days before starting work for all abatement projects (Rule 326.74). The Pollution Control Agency must be notified at least 20 days before a demolition (Rule 7005.1580, Subpart E).

94 Contractors must be licensed (Rule 326.72); workers and supervisors must be certified and complete State-approved initial training course (Rule 7005.1614 and Rule 326.73).

95 After the abatement is complete, the area must be cleaned with HEPA vacuums and wet methods until no asbestos dust is visible. The contractor must conduct a final visual inspection that meets the following requirements: (1) the inspection must be performed after the area has been cleaned and dried completely; any residue is considered asbestos and the cleaning/inspection sequence must be repeated until the area passes final inspection, and (2) a checklist (comparable to OSHA construction standard, Appendix F, Figure F-7) must be used; a minimum the inspection must consist of the following tests: (1) use a dark, damp cloth to collect dust from surfaces (with particular attention to horizontal surfaces) and then inspect cloth for evidence of dust, and (2) if possible, reduce lighting and inspect for residue using a flashlight to illuminate any smooth horizontal lines and run finger across illuminated area, noting if a line is left on the surface. After passing the visual inspection, porous surfaces stripped of asbestos containing materials must have a coating of an encapsulating agent to seal any residual fibers (Rule 7005.1616)

Clearance air sampling must be done with equipment that has been cleaned and decontaminated. Prior to monitoring, floors, ceilings, and walls must be blown with the exhaust of, at a minimum, a one horsepower leaf blower. Stationary fans must be placed in locations that do not interfere with monitoring equipment; fan air must be directed towards ceilings. One fan must be used for each 10,000 cubic feet of abatement area. A minimum of 5 must be collected simultaneously within each enclosed abatement area from sampling sites selected at random. The abatement project is considered complete when all samples are less than or equal to 0.01 f/cc by PCM.

For demolitions, clearance air sampling is required only if the area in which the abatement occurred will be used before the demolition by persons not involved in asbestos-related work. In this case, all surfaces not subject to aggressive air sampling must be encapsulated after post cleaning and after the area as passed visual inspection.

96 If bid exceeds $50,000 for a public project or $100,000 for a private project, contractor must obtain a certificate of responsibility from State (Amendments, Section 13). Management planners, project designers, inspectors, and supervisors must be certified; workers must be certified as individuals. No individual may perform asbestos removal unless certified. Training requirements are 3 day course for inspectors, 3 day plus 2 day course for management planners, 3 day designer course or 4 day contractor/supervisor course for project designers, 4 day course for contractors and supervisors, and 3 day course for workers. Inspectors require a 1/2 day annual refresher course and other require a 1 day annual refresher course (Regulations for the Accreditation and Certification of Asbestos Abatement Personnel, Appendix A).

97 Must notify 20 days in advance of project that exceeds NESHAP threshold. Contractor also must notify Department of Natural Resources within 60 days of project completion and include signed and dated disposal receipt (MORS 643.237.1).

98 Contractors must register annually. Project designers, supervisors, contractors, management planners, and inspectors must be certified; each must pass State examination and complete 1 day annual refresher course (1/2 day for inspectors). Workers do not require certification but training requirements apply (MORS 643.225).

99 Department of Health must inspect all publicly owned, leased, or operated buildings by the end of 1991; survey, reinspection, and management plan requirements are the same as AHERA requirements (MORS 701.122)

100 Establishes alternative practices for use in small asbestos projects affecting more than 3 square or linear feet and not exceeding NESHAP threshold when glove bag is neither large enough or of a proper shape to enclose the work area (019).

101 Requires HEPA filter equipped ventilation fans for enclosures so that air is exhausted continually from all locations within the work area (Title 178, Chapter 22 012.01D).

102 Saturate all exposed surfaces of the material to be removed with a water solution that contains an effective wetting agent; determine the effectiveness of the solution in penetrating the asbestos containing material by applying it to a small representative sample of the material before the project is initiated (013.01). "Amended water" is defined as a water solution containing an effective low sudsing wetting agent (002).

103 Notification of all asbestos projects must be submitted to Department of Health at least 10 days before the project is to start; a fee of $200 is charged for project review of projects exceeding NESHAP threshold (005).

104 Contractor must be licensed (LB 1073, Section 15; Title 178, Chapter 22, Sections 003 and 009). Certification required for inspectors, management planners, project designers, supervisors, and workers (Section 004). Training required for workers (3 days), supervisors (4 days), project designers (

105 After removal or encapsulation, clean plastic sheeting, surfaces, and equipment until free of all visible residue using HEPA vacuum or wet cleaning methods. For removal projects, coat cleaned surfaces from which asbestos has been removed with an effective color tinted sealing material; do not proceed to second cleaning until sealant has dried completely. Remove plastic sheeting from everything except the control curtains, containment barriers, and air tight seals over doorways, windows ventilation system, and other openings. Clean all previously covered surfaces free of all visible residue with HEPA vacuums or wet cleaning methods. Perform final cleaning within 24 hours after second cleaning is complete. Sweep air stream from high speed leaf blower or equivalent across all cleaned surfaced for not less than 5 minutes for each 1,000 square feet of surface area. Perform clearance air sampling with analysis by NIOSH 7400 method, the EPA TEM method, or equivalent. Operate HEPA filtered ventilation system for at least 24 hours after leaf blower action and until sampling shows airborne concentrations less than or equal to 0.01 f/cc by NIOSH 7400 method or 70 structures per square millimeter by the EPA TEM method.

106 Requires contractor to drain, collect and filter shower water through a system with the capability to collect particles 5 microns in size, at a minimum, and discharge into a sanitary sewer or other State or federal approved waste disposal system (012.02E5). Treat discarded filters as asbestos waste (012.02E6).

107 Defines project for the "abatement of asbestos" as involving more than 3 linear feet on pipes or 3 square feet on any other surface, except for emergency projects or spot repairs if the number of procedures can be predicted within 1 year and the material containing asbestos to be disturbed exceeds these limits (Section 46). This threshold triggers work practices, notifications, and clearance air monitoring.

108 Asbestos removal operations must comply with Appendix F and G of OSHA Construction Standard (Section 69).

109 Contractor must notify Division of Occupational Safety and Health at least 10 days before beginning job, in addition to NESHAP notification (Section 59). A request to remove asbestos from the outside of a building must be submitted before the 10 day advance notification; the request must contain an abatement plan that describes in detail how the project will be conducted (Section 69).

110 Contractors, supervisors, and workers must be licensed; inspectors, management planners, project designers, and project monitors must be certified. Training required for contractors (4 days), supervisors (4 days), workers (3 days), inspectors (3 days), management planner (5 days), project designer (3 days), and project monitors (4 days). (NAC 618, Sections 82 and 83, NRS 624.230).

111 After the work area has been washed and vacuumed, the area must be inspected for visible residue, recleaned where necessary and allowed to dry. Five air monitoring samples of 1,200 liters must be taken from each containment area at a maximum flow rate of 10 liters per minute. The average concentration of fibers must not exceed 0.01 f/cc. Building occupants may not be exposed in excess of 0.01 f/cc (8 hr TWA) as determined by TEM (NAC 618, Section 74).

112 Defines major asbestos abatement project defined as "Class N" for any project involving at least 260 linear feet, 160 square feet or 35 cubic feet; "Class S Demolition" for any project involving less than 260 linear feet, 160 square feet, or 35 cubic feet, and Class S Renovation" for any project involving less than 260 linear feet, 160 square feet and 35 cubic feet, but more than 10 linear feet, 25 square feet, or 3 cubic feet. A minor abatement job means any abatement renovation activity that involves no more than 10 linear feet, 25 square feet, or 3 cubic feet. Larger projects, divided into smaller segments, are still major projects. (ENV-C 402.20 - 402.23). Work practices and emission controls are required for major abatement projects that involve more than 10 linear feet or 25 square feet of friable asbestos; minor abatement jobs are exempt from license requirements for contractors and emission control requirements but must comply with specified work practices (HP 5019.01). Private single family residences occupied by the owner are excluded from requirements provided he performs the work himself and does not do so preparatory to selling the home (ENV-C 407.02).

113 Negative pressure ventilation units with HEPA filtration are required in sufficient number to provide one containment air change every 15 minutes and must be operated to maintain a static pressure differential of 0.02 inches water gauge for the duration of the project. Units must be exhaust filtered air to the outside of the facility wherever practical; if exhausted to interior spaces, a direct reading instrument equipped with a chart recorder must be located at the exhaust to continuously monitor fiber release or daily air samples, analyzed as quickly as practical, must be collected to monitor the exhaust (ENV-C 404.02(i)).

114 Requires notification of major asbestos abatements at least 10 days in advance and annual notification for continuous ongoing abatements (ENV-C 403.01 and .02).

115 Contractors must be licensed; training required for contractors (32 hours), workers and supervisors (24 hours), operations and maintenance workers and workers for minor projects (24 hours). Air sampling analytical service must be accredited by American Industrial Hygiene Association for asbestos analysis and participate in EPA bulk sample quality assurance program (HP 5011) Workers must be certified. No certification program in effect for others. (HR 5016).

116 Following abatement, wet cleaning shall be performed followed by HEPA vacuuming after surfaces have dried. The sequence of wet cleaning and vacuuming shall be repeated until no visible residue is observed after the last vacuuming. Clearance air sampling shall be conducted by an independent industrial hygienst and acceptable result must meet indoor air standard of 5 microns per cubic meter of air as determined by OSHA/NIOSH PCM methods, calculated as an 8 hr TWA. Air volumes taken for clearance sampling shall be sufficient to determine to a 95 percent probability fiber concentrations to 0.01 f/cc (ENV-C 404.02).

117 The Division of Public Services may inspect and obtain samples relating to asbestos abatement (RSA 141E:13); determination of the potential for human exposure shall be made in consideration of the proximity of friable asbestos to an air stream, the visibility and accessibility of the material, the degree of activity (movement, vibration) the friable material is exposed to, and the potential for a change in how the building is used (He-P 5011.03).

118 Defines "large asbestos hazard abatement job" as involving 160 square feet on equipment, wall, or ceiling are or the removal or encapsulation using a liquid material applied by pressurized spray of 260 or more linear feet on covered piping. A "small asbestos hazardous abatement job" involves the removal, enclosure, or encapsulation or more than 25 and less than 160 square feet or the removal or encapsulation of more than 10 and less than 260 linear feet on covered piping (5: 23-8.2).

119 Requires HEPA filtration units for large asbestos hazard abatement jobs in sufficient number and capacity to ensure that total air volume is exchanged once every 15 minutes (NJAC 5:23-8:10(c)(7)). For small jobs, fans or blowers shall not be used to ventilate tunnels, basement areas, or manholes before or during removal or repair work unless they are HEPA filtered (NJAC 5:23-8:11(b)(7)).

120 Use of wetting agents is required although the type is not specified; wetting agents must be tested on a small area first before using full scale to insure effectiveness (NJAC 5:23-8:11(b)(5)).

121 Large and small projects require an application and construction permit. The owner or agent also must notify the Department of Community Affairs within 3 days of issuance of construction permit (NJAC 5:23-8.6). A minor job (correction action for small damaged area of ceilings, pipe, and boiler insulation involving 25 square feet or less or removal or encapsulation using a spray or any other method for 10 linear feet does not require an application or construction permit (NJAC 5:23-8.2).

122 License required for employers (NJAC 12:120-4 and 8:60-4.1). Certification and training required for workers (including operation and maintenance workers) and and supervisors (4 days).

123 For large jobs: (1) clean all surfaces with amended water or removal encapsulant followed with wet wiping using disposable cloths; cloths shall be disposed of or rinsed thoroughly frequently enough to eliminate visible accumulation of debris and allow surfaces to dry, (2) notify Safety Technician in writing that a presealant inspection is requested, (3) upon receiving a satisfactory inspector, spray coat all dried exposed surfaces with a sealant, including polyethylene sheeting on walls, floors, fixtures, and equipment (the color of the sealant must be distinct from the underlying substrate), (4) remove plastic sheeting (except decontamination barriers), (5) wet clean with amended water or a removal encapsulant all surfaces; allow to dry and repeat procedure. After completion of cleaning, notify monitor that a cleanup inspection is needed and request air monitoring. For small jobs, the work area must be thoroughly HEPA vacuumed and wet mopped before any sheeting is taken down (NJAC 5:23-8:11)

Sampling begins at least 24 hours after wet cleaning has been completed. Use propeller type fans (minimum 1 foot blades and air velocity of 500 feet per minute) or leak blower. On representative sample is required for every 10,000 square feet of floor space in the work area. Every sample must demonstrate less than 0.010 f/cc. Failure requires recleaning (NJAC 5:23-8:15). For small projects, a final air sample is taken to ensure that the fiber concentration is 0.010 f/cc or lower for every 10,000 square feet of floor space contained by the critical barrier (NJAC 5:23-8:1).

124 In large jobs, all free water (in contaminated areas) shall be retrieved and added to asbestos contaminated waste and/or placed in plastic lined leak-tight drums and/or solidified with an acceptable polymer (NJAC 5:23-8.10(f)(9)).

125 Contractor must have general contractor license; must complete EPA sponsored or approved training course (Licensing Act of 1978).

126 Required work practices apply to large (NESHAP threshold, including multiple locations) and small projects (installation, removal, disturbance, enclosure, or encapsulation of more than 10 and less than 160 square feet or more than 25 and less than 260 linear feet) (12 NYCRR Part 56, Section 56-1.4, 56-5.1, 56-6.1, 56-8.1)

127 For New York State and New York City, negative air ventilation units shall be exhausted to the outside of the building; air monitoring and daily inspections are required to insure that the ducts do not release asbestos into uncontaminated areas (56-6.1) Negative air systems must be operated according to "Specifications and Operating Procedures for the Use of Negative Pressure Systems for Asbestos Abatement, Guidance for Controlling Asbestos Containing Materials in Buildings" EPA 560/5-85-024 (1985).

128 Any surfactant used must be noncarcinogenic and not generally toxic in normal use (56-7.1).

129 In New York State, notification is required for large abatement projects (NESHAP); in New York City, notification (including inspection report) is required as part of building permit for large and small projects. A 7-day notice to all building occupants in English and Spanish, also is required (NYC Section 8211).

130 Contractors must be licensed; certification and training required for workers and supervisors (18 hours). Operation and maintenance workers/minor project workers (less than 25 square or linear feet) must be trained Part 56-2). New York City requires certification and training for investigators (3 days), workers (4 days), and supervisors (5 days) (Sections 8111, 8115).

131 For the first cleaning, all surfaces must be wet cleaned using rags, mops, and sponges and the first layer of plastic sheeting be removed from walls and floors. A second cleaning at least 12 hours later using wet cleaning and.or HEPA vacuuming is required and remaining plastic on walls and floors removed. A third cleaning at least 12 hours later is required and all containerized waste must be removed from the work area and holding area. Clearance air monitoring is required for large and small projects, minor projects, and demolitions.

For large projects, at least 5 samples inside and 5 samples outside the work area are required, plus 1 area sample for every 5,000 square feet above 25,000 square feet of floor space. For small projects, a minimum of 3 samples inside and outside the work area are required. If negative ventilation exhaust ducts run through uncontaminated areas, an additional exterior area sample must be taken. Every sample must be less than 0.01 f/cc.

132 Shower water shall be drained, collected, and filtered through a system with at least 5 micron particle size collection capability. A system containing a series of several filters with progressively smaller port sizes shall be used to avoid rapid clogging of the filtration system by large particles. Filtered wastewater shall be discharged in accordance with applicable codes; contaminated filters shall be disposed of as asbestos waste (56-9.1).

133 HEPA filtered exhaust system to maintain 0.02 inches of water negative pressure required for state-owned buildings;air must be exhausted outside the building and the exhaust system monitored daily for leaks. Contractor must use new HEPA filters or show that each filter meets performance standards (Specifications IV(C)(4)).

134 Asbestos shall be sprayed with water containing an appropriate wetting agent; the agent shall be in a concentration recommended by the manufacturer (Specifications IV(D)).

135 In addition to NESHAP notification, contractor must provide notification for any work in a state-owned building (Specification I(C)(1)).

136 Contractors must obtain a general contractor license if undertaking project of $30,000or more and be certified in one of three areas (Chapter 87-1 and Administrative Code,Title 21, Chapter 12.0202). Consultants and industrial hygiene firms must be accredited. To bid on state-owned building projects, contractors must complete a contractors or supervisors course that meets AHERA and a NIOSH or AIHA respiratory course; workers must receive training that meets AHERA requirements. Air monitors must have received a contractors or supervisors course that meets EPA-AHERA regulations and a NIOSH/AIHA respiratory course; all technicians must be certified. Persons exempt from accreditation requirements include: owner/operator of nonschool buildings performing asbestos management in nonpublic area, person performing asbestos management in own residence, government personnel performing asbestos management under federal, state, or local authority, and persons licensed by General Contractors Licensing Board, State Boards of Plumbing and Heating, or Electrical and Refrigeration Contractors when less than 260 linear or 35 cubic feet is involved and they are working under the supervisor of an accredited supervisor (Specifications, IIA).

137 Equipment must be cleaned and all contaminated materials removed before removing sheeting from walls and floors. Contractor must clean all surfaces, including ducts, electrical conduits, steel beams, etc. with water and/or HEPA vacuums. A second cleaning is required after 24 hours. After the second cleaning, the contractor must perform a visual inspection to confirm that the work area is dust and fiber free. A complete visual inspection is then made by a certified industrial hygienst. Air samples are than taken (maximum flow rate of 2-12 liters per minute and minimum sample size of 3000 liters); all fiber concentrations must be below 0.01 f/cc 5 microns in length. Repeat cleaning, inspection, and sampling is required if samples are not in compliance. The contractor must provide documentation that the building has been certified clean by the certified industrial hygienst (Specifications, IV(.08), II(E), III(C).

138 All excess water (except shower water) shall be (1) combined with the waste material or other absorptive material and disposed of as waste or (2) HEPA filtered and disposed of in the normal sewer system (Specifications, IV(D)).

139 Work practices are applicable to any demolition or renovation involving the stripping or removal of friable asbestos (Administrative Code, Section 33-15-13.02)

140 Written notification required for all demolition projects containing friable asbestos and renovations involving more than 160 square feet of asbestos (Administrative Code, Section 33-15-13.02)

141 Contractor must obtain general license for all construction activities with fees over $500. Employees must be certified and trained (regulations not in effect at this time).

142 Notification and contractor license required for all jobs exceeding 50 square or linear feet (OAC Section 3710.05).

143 Contractor license required for all abatement activities over 50 square or linear feet (OAC Section 3710.05). Workers and consultants must be trained and certified; workers require 19/5 hours of training, 20 for consultants. Supervisors require 26 hours of training (Department of Health, 3701-34-07(F)).

144 Work practices and engineering controls are applicable to all abatement projects; special requirements are applicable to glove bag operations involving less than 20 linear feet (Rule 8.00.00.00).

145 Pressure differential devices shall be equipped with HEPA filters (Rule 9.03.01).

146 Surfactants shall be a 50/50 mixture of polyoxyethlylene ether and polyoxyethylene ether, or equivalent, mixed in a proportion of one fluid ounce to 5 gallons of water or as specified by the manufacturer (Rule 9.02.04).

147 Contractors must notify the Commission of Labor 20 days prior to any abatement work and submit a new notification if he does not meet the project start date (Rule 5.01 and 5.06). Glove bag operations involving less than 20 linear feet are exempt if the owner has provided within 30 days a complete list of all such operations for the previous month to the Commissioner of Labor (Rule 7.02.01). Contractors may not begin any job until authorization received from the Commissioner of Labor and documentation and required materials for prior jobs have been received by the Commissioner of Labor (Rule 5.03.02).

148 Contractor must obtain a license; attendance of at least 2 approved courses is required to obtain a license (Rule 3.02.01.02). Annual review course also is required (Rule 3.02.08). Workers must be certified and receive initial course same as for contractors and annual refresher course. AHERA inspectors must receive 24 hours of training, management planners must receive 24 hours plus 16 hours;, project designers must meet requirements for contractor Rule 3.02 and 3.04).

149 Place all visible accumulations of asbestos materials and debris in containers utilizing rubber dust pans and squeegees to move material about. Wet clean all surfaces and remove the cleaned outer layer of sheeting from walls and floors. Wait for surfaces to dry and HEPA vacuum and wet clean all surfaces again. Inspect the work area for visible residue; if residue is observed, cleaning cycle shall be repeated. After work area is free of visible residue, apply a thin coat of a satisfactory lock-down agent to all surfaces in the work area to seal in nonvisible residue (Rule 9.08.08).

The contractor notifies the Commissioner of Labor for a visual inspection. A minimum of 1 test sample is required for each 1500 square feet for clearance monitoring; at least 1 sample per room is required (Rule 6.02.02.01). Samples must be taken over a 6 hour period, if shorter periods are used, there must be a proportionally greater number of samples taken. To be approved, the fiber concentrations must be less than 0.005 f/cc by PCM or the airborne fiber concentration outside the contaminant as determined prior to abatement, whichever is greater. For any school abatement involving more than 3,000 square feet or 1,000 linear feet, the samples must be less than 0.005 f/cc by TEM (Rule 6.02.03).

150 Work practices and controls are applicable to all abatements except: (1) the removal of 3 square or linear feet (provided that the removal is not the primary objective and methods of compliance for small scale short durations are met; a project may not be subdivided into smaller size units to meet this exemption), (2) removal of nonfriable asbestos (exemption ends whenever material becomes friable), (3) removal of materials sealed in rigid casing (provided casing is not broken or altered to allow releases), and (4) abatements conducted in private residences by homeowners (340-25-465)

151 whenever feasible, the employer shall establish negative pressure enclosures for removal, demolition, and renovation operations. However, requirements for engineering controls specify that local exhaust ventilation must be equipped with HEPA filter dust collection systems (OAR 437-83-7030(1)(a)(A).

152 Contractors must notify Department of Environmental Quality at least 10 days before any abatement project; new notification is required if location and size category changes. (OAR 340-25-465). Annual or monthly project notification is required for projects less than 40 linear or 80 square feet.

153 Contractors must be licensed annually for small scale or large scale abatements (OAR 340-33-040). Certification required for workers (3 days training for large scale abatement or 2 days for small scale abatement with 1 day annual refresher course) and supervisors (4 days training with 1 day annual refresher and be certified as a worker (OAR 340-33-050,070).

154 Clearance monitoring shall not exceed 0.05 fibers greater than 5 micrometers in length (OAR 437-115-010); provisions for cleanup prior to monitoring not specified.

155 All external surfaces in any place of employment shall be maintained free of accumulations of asbestos fibers (437-115-045).

156 Work practices and controls apply to any abatement job greater than 10 linear feet on pipe o4 25 square feet on other surfaces (R23-24.5, B.8.1)

157 Negative pressure ventilation units with HEPA filtration shall be operated continuously from the time of barrier construction through the time of acceptable clearance air monitoring results; units shall exhaust filtered air to the outside of the building. Filtered air shall not be exhausted to uncontaminated interior spaces (R23-24.5, B.8)

158 Contractor must notify Department of Health at least 10 days before beginning any onsite work at a planned abatement project (R23-24.5(B)(2)(1)). Clearance air monitoring results must be reported to Department of Health within 3 working days of receipt (R 23-24.5(B)(2)(2). Owner must notify Department of Health to confirm disposal; if confirmation is delayed more than 20 days, owner must investigate status of shipment and report results (R 23-24.5, C.1).

159 Contractor must obtain 2 year license (23-24.5-12 of General Laws and R23-24.5, B.1). Consultants must be certified. Operation and maintenance workers must complete certified training course. Workers and supervisors must complete initial training course of 4 days with 1 day annual refresher course; supervisors must complete an additional 6 hours of training (R23-24.5 ASB, B and D).

160 Establishes bulk sampling protocol for hazardous assessment of public and private building by the Department of Health for abatement program (R23-24.5 ASB, Part E, Appendix A).

161 Cleanup procedures using wet cleaning with an amended water solution followed by HEPA vacuuming are required. The sequence of wet cleaning followed by HEPA vacuuming shall be repeated at 24 hour intervals until no visible residue is observed in the work area (R23-24.5, B.8). Clearance air monitoring is required for all projects except spot repairs (i.e., less than 10 linear or 25 square feet). A minimum air volume of 1000 liters shall be sampled; sampling shall be conducted in representative locations with portable fans circulating to simulate actual use conditions. An acceptable airborne fiber concentration shall not exceed 0.01 f/cc for fibers greater than 5 microns in length or 300 namogram per cubic meter. Samples shall be collected and analyzed by NIOSH 7400; results must indicate what counting rules were used. (R 23-24.5 ASB, C.1).

162 The Department of Health must conduct inspections of public and private high priority buildings; building owners notified of a health violation must submit an abatement plan (Title 23, Chapter 24.5-7). Building owners must appoint an competent person to inspect known asbestos area, review past maintenance records, maintain records, make periodic inspections of abatement projects, and review abatement work (Chapter 24.5-7).

163 Work practices also are prescribed for small projects (under NESHAP threshold) and minor projects (less than 25 square or 10 linear feet).

164 Negative pressure ventilation units with HEPA filtration shall be operated for the duration of projects over NESHAP threshold. Filtered air shall be exhausted to the outside of the building where feasible; if exhausted to uncontaminated interior spaces, a continuous monitor (with a chart recorder is recommended (SCRR 61-86.5.1.1.5).

165 Notification required for small projects (between 10 and 160 linear or 25 to 260 square feet) to District Office of Department of Health 5 days in advance; 5 day period may be waived on a case by case basis (SCRR 61-86.11.2.1). For minor projects, a log of all projects must be submitted within 30 days of the end of each quarter (SCRR 61-86.6.11.2.3).

166 Contractor must obtain license for all friable asbestos work (SCRR 61-86.6.1.1). Workers, supervisors, and consultants must be licensed. Licensure requirements include initial training course for workers with annual review course. Requirements for supervisors, consultants, and air monitors include initial worker training course and EPA approved course for supervisors (roofer supervisors must take special source). (SCRR 61-86.4.1, 86.6).

167 Following abatement, cleanup procedures using wet cleaning with amended water solution, followed by HEPA vacuuming after surfaces have dried is required; the cleaning sequence must be repeated at 24 hour intervals until no visible residue is observed in the work area. For clearance air monitoring, at least 5 samples are required and 1 representative sample for every 10,000 square feet of floor space. Air sampling must provide statistically reliable results of less than 0.1 f/cc using PCM or equal to or less than fiber concentration in outside air using TEM or SEM methods (SCRR 86.4.3.4.5). Clearance air sampling is not required following asbestos removal for demolition purposes unless the area is to be utilized by unprotected personnel prior to demolition. Visual inspection must be performed upon completion of the removal to ensure that all material has been removed (SCRR 61-86.5.1.5.2.2).

168 Notice of intent to demolish or renovate a building containing friable asbestos must be submitted to EPA Region VIII and Department of Water and Natural Resources (no citation).

169 Contractor must be certified, use certified workers, and complete approved training. Management planners, abatement project designers, and inspectors must be certified. Workers must have 3 days training and 1 day annual refresher course, contractors and supervisors must have 4 days training, management planners (2 days), project designers (3 days), and inspectors (3 days) and pass an examination every 3 years for recertification (ARSD 74:31:03:04).

170 Owner or operator must notify Technical Secretary of all demolition projects (and all projects exceeding NESHAP threshold) at least 10 days before beginning job (1200-3-22.02).

171 Contractor must obtain specialty license: licensure requires contractor to have at least 1 employee who has completed training course (0680-1.16, Appendix A). No training or certification regulations are in effect.

172 Contractors must notify Department of Public Health 10 days before beginning any asbestos related activity in a public building (Section 289.147).

173 Contractor must have annual license; requires that at least 1 licensed supervisor oversee asbestos operations (Sections 289.143 and .144). Employees must be registered with the Department of Health (Section 289.149); workers and supervisors must have EPA approved 32 hour initial training course and 1 day annual refresher course.

174 Work practices are specified for large projects (NESHAP threshold) and for smaller projects based on glovebags (R446-1-8.6).

175 Negative pressure ventilation systems with HEPA filtration are required for the duration of job for projects exceeding NESHAP threshold. Filtered air shall be exhausted to the outside of the building where practicable (R446-1-8.6).

176 Contractor must notify at least 20 days in advance of demolition of structures containing less than NESHAP threshold (R446-1-8.5).

177 Contractor must be certified and must ensure that at least 1 contractor's representative has proper training (R446-1.8.3). Contractor's representative must have 4 day initial training course and 1 day annual refresher course. Workers must have 1 day initial training course and 1/2 day annual refresher course (R446-1.8.4). No certification requirements are currently in effect.

178 Contractors must notify Department of Labor at least 20 days prior to a project; small projects (less than 10 linear or square feet) are not required to report but must maintain records (Code, 54-145.10:1 and 1988 Interpretation).

179 Abatement contractors, including roofing, flooring, and siding contractors, must be licensed (Section 54-1501 and Part III, Section 3) and complete approved training course. Certification is given upon completion of training. workers must complete 3 days training, contractors and supervisors (4 days), inspectors (3 days), project designers (3 days), and management planners (2 days); each must complete an annual 1 day refresher course except inspections, who require a 1/2 day annual refresher course (Part VII, Section 7.1).

180 Establishes protocol for bulk sampling conducted for inspections of commercial and public buildings, hospitals, child care centers, and buildings built before 1978 that are being converted to condominiums (Survey Standards, Section VI).

181 "Asbestos abatement" is defined as an activity involving more than 10 linear feet on pipes or 25 square feet on any other surface (18 VSA Chapter 26, Section 1.2.7).

182 Negative pressure ventilation units with HEPA filtration must be operated for the duration of the project; filtered air shall be exhausted to the outside of the facility wherever feasible. If exhausted to the interior, a direct reading instrument equipped with a chart recorder or daily air sampling is required (Section 2.5.2).

183 Notification required 10 days prior to beginning project for abatements over 10 linear feet on pipes or 25 square feet (Section 2.2).

184 Contractors must obtain annual certification except for spot repairs on pipes up to 10 linear feet or 25 square feet on other surfaces or activities involving asbestos floor tiles, roofing shingles, or siding (Section 2.01.02). Consultants and industrial hygiene firms also must be certified; 4 days training required. Workers and supervisors must be certified; 1 day training required for workers and 4 days training required for supervisors (section 2.03). Annual 1 day review course required for workers and supervisors (Sections 2.03 and 2.04).

185 Bulk sampling methodology using PLM with dispersion staining and quality assurance requirements are established for laboratories performing analyses for inspections of public buildings (Section 3.02).

186 Following abatement, wet cleaning followed by HEPA vacuuming must be performed; the cleaning sequence shall be repeated at 24 hour intervals until no visible residue is observed in the work area (Section 2.5). Air samples for clearance air monitoring shall be sufficient to accurately determine (to a 95 percent probability) fiber concentrations to 0.01 f/cc. Sampling shall be conducted in representative locations with portable fans, leaf blowers, or other equipment circulating air to simulate actual use conditions (Section 2.5.2). Clearance monitoring is not required after removal of asbestos prior to a demolition unless the area is to be entered by unprotected personnel prior to demolition or reoccupied after partial demolition (Section 2.5.6).

187 Public buildings must surveyed by certified consultants (Statutes, Section 123).

188 Where feasible, the employer shall establish negative pressure enclosures and ensure that engineering controls, including HEPA filters, are properly operating (WAC 296-62-07712).

189 A written report describing preabatement inspection for asbestos or a statement of assumption of the presence or reasonable certainty of the absence of asbestos must be included as part of the notification (SHB 1592, Section 7). Notification also is required for projects 11 square feet on surface area or 10 linear feet on pipes or more; notification is not required for projects under this level (Section 13).

190 Contractors must obtain an asbestos contractor certificate and have at least 1 certified supervisor (1592, Section 11); a certified supervisor is not required for projects under 48 square feet or 10 linear feet. Certification for workers and supervisors requires 30 hours of training and an annual 7 hour refresher course (WAC 296-65-005 and 010).

191 Notification to the Department of Health is required for all abatement projects 20 days before beginning of the job (Section 16-32-6).

192 Contractors, management planners, and inspectors must be licensed; licensure requires each to complete an EPA approved training course. Training regulations are not currently in effect.

193 Apartment buildings of 4 units or less are not exempted by definition (NR 447.02); work procedures apply to all projects over 160 square feet or 260 linear feet (NR447.06).

194 Contractor license is not required. Workers, contractors or supervisors (a contractor may designate the supervisor to serve as his agent for accreditation), inspectors, planners, and designers required certification only for work in public buildings. Workers must have 3 days training, contractors or supervisors (4 days), inspectors (3 days), planners (3 days plus 2 day management course), and designers (3 day course for designers or 4 day course for contractors and supervisors). Each must complete a 1 day annual refresher course except for planners, who require a 1 1/2 day annual refresher course (Asbestos Education Accreditation Plan, Sections 1 and 3 D).

TABLE 3. COMPARISON OF REGULATORY BASELINE AND ALTERNATIVES FOR WASTE HANDLING, TRANSPORTATION, AND DISPOSAL

REGULATORY BASELINE	REGULATORY ALTERNATIVES[1]									
	INACTIVE SITES	WORK PRACT. 1	WORK PRACT. 2	INTER-MEDIATE COVER	COVER COMPAC-TION	FINAL COVER	STORAGE/ TRANSFER	D & R WASTE	VEHICLE COVER	VEHICLE DECONTAM-INATION
FEDERAL										
EPA NESHAP (40 CFR 61, Subpart M)	NO[2]	NO[3]	NO[4]	NO	NO[5]	NO[6]	NO	NO	NO	NO
EPA AHERA (40 CFR 763, Subpart E, Appendix D)	NO	NO[7]	NO[8]	NO[9]	NO[10]	NO[11]	NO[12]	NO	YES[13]	NO[14]
EPA RCRA Guidelines For Land Disposal of Solid Wastes (40 CFR 241)	NO	NO	NO[15]	NO[16]	NO[17]	NO[18]	NO	NO	NO	NO
EPA RCRA Criteria For Classifi-cation of Solid Waste (40 CFR 257)	NO	NO	NO	NO[19]	NO	NO	NO	NO	NO	NO

REGULATORY BASELINE	REGULATORY ALTERNATIVES[1]									
	INACTIVE SITES	WORK PRACT. 1	WORK PRACT. 2	INTER-MEDIATE COVER	COVER COMPAC-TION	FINAL COVER	STORAGE/TRANSFER	D & R WASTE	VEHICLE COVER	VEHICLE DECONTAM-INATION
EPA RCRA Proposal for	NO	NO	NO[20]	NO	NO	NO	NO	NO	NO	NO
Solid Waste Municipal Landfills (40 CFR 257 and 40 CFR 258)	NO[21]	NO	NO[22]	NO	NO[23]	NO[24]	NO	NO	NO	NO
OSHA Workplace (29 CFR 1910.1001	NO	NO[25]	NO	NO	NO	NO	NO	NO	NO	NO
OSHA Construction (29 CFR 1926.58)	NO	NO[26]	NO	NO	NO	NO	NO	NO	NO	NO
DOT (49 CFR 171, 172, 173, 174)	NO	NO[27]	NO	NO	NO	NO	NO	NO	NO	NO
STATES	YES[28] (13/51)	YES[29] (35/51)	YES[30] (31/51)	YES[31] (29/51)	YES[32] (8/51)	YES[33] (45/51)	YES[34] (20/51)	NO[35] (0/51)	YES[36] (14//51)	YES[37] (4/51)

CODE: "NO" means that the existing rule does not contain the requirements addressed by a regulatory alternative. "YES" means that the existing rule includes a provision similar to or the same as the regulatory alternative.

1 See Attachment 1 for description of regulatory alternatives.

2 Inactive waste disposal sites for mills, manufacturing, and fabricating operations must discharge no VE or be covered with 6 inches of compacted nonasbestos material and vegetated, or covered with 2 feet of compacted nonasbestos material. Inactive tailings disposal site require a resinous or petroleum-based dust suppression agent. Fencing and warning signs also are required to deter public access (40 CFR 61.153).

3 For mill waste: (1) discharge no VE during the collection, processing, transporting, or deposition of the waste or use a wetting agent to effectively wet dust and tailings with no VE from wetting or use air cleaning to control emissions, or (2) or use an approved alternative. For waste from manufacturing, demolition, renovation, spraying, and fabricating operation: (1) discharge no VE during the collection, processing (including incineration), packaging, transporting, or deposition of waste, (2) treat with water (form a slurry for control device waste and adequately wet other material) and discharge no VE from wetting or use air cleaning to control emissions and after wetting, seal all waste material in leak-tight containers while wet and label, or (3) process waste into nonfriable forms and discharge no VE or use air cleaning for emissions, or (4) use an approved alternative (40 CFR 61.151 and 61.152).

4 For active waste disposal sites, discharge no VE or cover with 6 inches of compacted nonasbestos material at the end of the operating day or at least every 24 hours while the site is in continuous operation or apply dust suppressant, or use an approved alternative (40 CFR 61.156).

5 The 6 inch cover for active and inactive sites must be compacted nonasbestos material.

6 For inactive sites, a 2 foot final cover can be used as an alternative to a 6 inch vegetated cover (40 CFR 163).

7 Requires that waste, including all debris, filters, mopheads, and cloths from cleaning prior to response actions and all debris and other cleaning material from operation and maintenance activities be disposed of in sealed, leak-tight containers according to NESHAP. (29 CFR 763.91(c)).

8 For waste disposal from school abatements, Appendix D to 40 CFR 763, Subpart E recommends, but does not require, that landfill operator inspect the waste at the gate to verify proper containment. A chain-of custody form should be signed over to the disposal site operator to transfer responsibility for the waste and a signed copy maintained by the transporter. The asbestos waste should be disposed of in a separate trench in an area of the landfill set aside only for asbestos waste. The trench should be ramped to allow the transport vehicle to back into it, and the trench should be as narrow as possible to reduce the amount of cover required. The containers should be carefully placed in the trench to avoid breakage, particularly if the containers are plastic bags. A record of the specific quantity and waste and location of the waste in the landfill should be maintained for future landowners. The area should be fenced when natural barriers do not exist and warning signs should be posted. The waste should be completely covered with a minimum of 6 inches of nonasbestos material within 24 hours.

9 For waste disposal from school abatements, Appendix D to 40 CFR 763, Subpart E recommends, but does not require, application of the intermediate cover before the waste is compacted or heavy equipment run over it. During compacting, the operator should avoid exposing wastes to the air or tracking asbestos material away from the trench.

10 See footnotes 9, 10, and 12 for compaction recommendations.

11 For waste disposal from school abatements, Appendix D to 40 CFR 763, Subpart E recommends, but does not require, a final cover (for final closure of an area containing asbestos waste) of at least an additional 30 inches of compacted nonasbestos material to provide a 36-inch cover. The final cover should be properly graded and vegetated. In areas where excessive soil erosion may occur or the frost line exceeds three feet, an additional final cover should be used. In desert areas where vegetation would be difficult to maintain, 3-6 inches of well graded crushed rock is recommended for placement on top of the final cover.

12 For waste disposal from school abatements, Appendix D to 40 CFR 763, Subpart E recommends, but does not require, that vehicles that use compactors should not be used. Vacuum trucks carrying slurry should be inspected to ensure no water is leaking. Also, a landfill approved for receipt of asbestos waste should require notification from the transporter that the load contains asbestos.

13 For waste disposal from school abatements, Appendix D to 40 CFR 763, Subpart E recommends, but does not require, that transport vehicles have an enclosed carrying carrying compartment or use a canvas cover sufficient to contain the waste, prevent damage to containers, and prevent fiber release. Roll off boxes also should be covered.

14 For waste disposal from school abatements, Appendix D to 40 CFR 763, Subpart E recommends, but does not require, that if improperly containerized waste is received at the site, the landfill operator should soak the waste with a water spray prior to unloading, rinse out the truck, and immediately cover the waste with nonasbestos material prior to compacting in the landfill.

15 The existing guidelines for land disposal of solid waste (40 CFR 241) recommend, but do not require, an initial, compacted cover of at least 6 inches applied the same day.

16 The existing guidelines for land disposal of solid waste (40 CFR 241) recommend, but do not require, an intermediate cover of at least 1 foot for areas where additional cells are not to be constructed for extended periods of time (1 week to 1 year).

17 The guidelines recommend a compacted initial, intermediate, and final cover.

18 The existing guidelines for land disposal of solid waste (40 CFR 241) recommend, but do not require, a final cover of at least 24 inches applied on each area as it is completed or if the area is to remain idle for more than 1 year.

19 The criteria for classification of solid waste disposal and practices (40 CFR 257) requires periodic application of cover material or other appropriate techniques. The standards do not include any provisions specific to asbestos or to daily, intermediate, and final cover requirements.

20 The proposed amendments to 40 CFR 257 do not revise the existing requirements for periodic application of cover material or other appropriate techniques at solid waste disposal facilities; proposed revisions would require information to be submitted to aid EPA in developing information on the 28,000 industrial solid waste disposal facilities and the 2,600 construction/demolition landfills.

21 Proposed provisions of 40 CFR 258 are specific to municipal landfills and would would establish minimum criteria for closure of active sites, including development of a closure plan and post closure care for 30 years, but would not apply to facilities already closed.

22 Proposed provisions of 40 CFR 258 would require application of a suitable cover at the end of each operating day (or at more frequent intervals) at new and existing municipal solid waste landfills; the type and minimum depth is not specified, but at least six inches of daily cover is recommended. States may waive the daily cover requirement on a case-by-case basis in the event of extreme seasonal climate conditions. The proposed cover criteria are for vector control and do not include any provisions specific to asbestos.

23 Proposed provisions of 40 CFR 258 for cover materials (40 CFR 258.21) do not establish requirements for cover compaction; at least six inches of compacted earthern materials applied daily is recommended.

24 Proposed provisions of 40 CFR 258.21 establish general performance standards for final cover. Existing units must be equipped at closure with a final cover system designed to prevent infiltration of liquid through the cover and into the waste. New units must meet health-based design goals. No technical requirements for the amount of final cover are specified; States are encouraged to establish specific technical requirements.

25 The DOT rules for hazardous wastes (listed under RCRA Subtitle C) generally require shipment in closed head drums (49 CFR 171.3). Asbestos is classified as an "other regulated material" (ORM-C) rather than a hazardous waste. As such, shipping papers are required, but not hazardous waste manifests. There are no specific provisions for transportation of asbestos waste. The DOT rules for labeling and packaging apply only to the transportation of commercial asbestos; asbestos that is fixed in a natural or artificial binder (e.g., cement, plastic, asphalt, resins, mineral ore) and manufactured products or products whose commercial value is not dependant on asbestos content are exempt (40 CFR 172). Commercial asbestos must be transported in bags or other nonrigid packaging in closed freight containers, motor vehicles, or rail cars loaded by and for the exclusive use of the consignor and unloaded by the consignee (49 CFR 173). The bags or nonrigid packaging must be dust- and shift-proof or strong and shift-proof in strong external fiberboard or wooden boxes. Shipping papers are required as asbestos is classified as an "other regulated material" (ORM-C) and not as a Subtitle C hazardous waste. When transported by rail, asbestos must be loaded, handled, and unloaded, and any asbestos contamination of the rail car removed in a manner that will minimize occupational exposure to airborne asbestos particles released during transportation (49 CFR 174).

26 29 CFR 1910(k) requires that all surfaces be maintained as free as practicable from accumulations of dust and waste. All spills must be cleaned up as soon as possible. Shoveling, dry sweeping, and dry cleanup may be used only where vacuuming and/or wet cleaning are not feasible. Waste, scrap, debris, bags, containers, equipment, and contaminated clothing consigned for disposal must be disposed of in sealed, impermeable bags, or other closed, impermeable containers.

27 29 CFR 1926.58(l) requires waste, scrap, debris, bags, containers, equipment, and contaminated clothing consigned for disposal to be collected and disposed of in sealed, labeled, impermeable bags or other closed, labeled, impermeable containers.

28 Thirteen (13) of 51 states have specific provisions in solid waste management regulations that address inactive site disposal sites. These are: Alabama, Alaska, Arkansas, Colorado, Connecticut, Minnesota, Missouri, Nebraska, New Mexico, South Dakota, Tennessee, Utah, and Virginia. Of these states, only Colorado, Connecticut, and New Mexico are asbestos specific. In general, the states require a 2 foot final cover or require that the site meet closure standards for active sites.

29 Thirty-five (35) of 51 states specify waste handling practices prior to disposal. These states are: Alabama, Alaska, Arizona, Arkansas, California, Colorado, Connecticut, Delaware, Georgia, Hawaii, Illinois, Indiana, Kansas, Louisiana, Maine, Maryland, Massachusetts, Minnesota, Nebraska, Nevada, New Hampshire, New Jersey, New Mexico, New York, North Carolina, North Dakota, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Carolina, Utah, Virginia, and Vermont. In California, asbestos is classified as a hazardous waste; a hazardous waste manifest and packaging in a closed head drum is required. Waste manifests also are required by North Dakota, Georgia, and Louisiana. Notification to the disposal site prior to delivery is required in Oregon, Delaware, Indiana, Hawaii, Kansas, and Maryland. A few states require cleaning the bags prior to disposal by wet wiping or HEPA vacuuming; others may require thorough wetting or soaking prior to containerizing. In the latter case, Colorado and Connecticut require the use of amended water for this purpose. Several states specify that contaminated clothes and cleaning materials also must be disposed of as asbestos waste. In nearly all cases, the state regulations apply only to friable asbestos.

The major focus of the work practices instituted prior to disposal is preparation of the waste. Twenty one of the 35 states specify the use of a single 6 mil polyethylene bag in a drum, double 6-mil bags, drums for objects with sharp edges likely to tear bags, and/or double 6 mil sheets for large structural units removed intact. Two states allow double 4 mil bags and 5 states allow single 6 mil bags.

30 Thirty-one (31) of 51 states require specific work practices for asbestos waste at the land disposal site in addition to the 6 inch cover applied by the end of the operating day as required by the NESHAP. These states are: Alabama, Alaska, Arizona, Arkansas, California, Colorado, Connecticut, Delaware, Florida, Georgia, Illinois, Indiana, Kentucky, Maine, Massachusetts, Michigan, Minnesota, New Jersey, New Mexico, New York, North Carolina, Oklahoma, Oregon, Pennsylvania, Rhode Island, South Carolina, Texas, Utah, Virginia, Vermont, and West Virginia.

These states have applied many different types of provisions, such as inspection for proper containerization by the disposal site operator, requirements for burial in a separate cell and/or trench (some states allow burial in the active face of the landfill under certain conditions), application of cover material immediately upon receipt, and different requirements for cover material, among others. States that require an initial cover (i.e., 1 foot in Alabama, 9 inches in Connecticut, 2 feet of solid waste or soil or 4 feet if in a separate pit, 3 feet of cover in New Jersey, 2 feet of cover in Oregon, 2 feet of solid waste or 6 inches of earth in Rhode Island, 1 foot of earth or 3 feet of solid waste in Texas, 1 foot of soil in Virginia and in West Virginia) do not require an intermediate cover. States that require the 6 inch initial cover also apply an intermediate cover under solid waste management rules.

31 Twenty-nine (29) states require an intermediate cover in addition to the initial 6 inch cover under solid waste management regulations. These states are: Arkansas, Colorado, Connecticut, Delaware, Florida, Georgia, Hawaii, Idaho, Illinois, Indiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Missouri, Nevada, New Hampshire, New York, North Carolina, Ohio, Oklahoma, Pennsylvania, Rhode Island, South Carolina, Tennessee, Vermont, Wisconsin, and Wyoming. Intermediate covers typically are applied over the initial cover and must be applied within a specified time after completion of the lift. Five states require a depth of an additional 6 inches (in time periods ranging from 48 hours to 6 months). The remaining states require 1 foot of intermediate cover (in time periods ranging from completion of the lift to 9 months after completion of the lift).

32 Eight (8) states apply specific provisions regarding the compaction of cover for asbestos wastes. In all other states, the cover material (and the waste) is compacted. These states are: Alabama, Arizona, Arkansas, New Mexico, Oregon, Pennsylvania, Virginia, and West Virginia. In Pennsylvania, the initial cover is not compacted; the other states do not allow compaction until initial cover has been applied.

33 Nearly all states (45) specify requirements for final covers at solid waste disposal facilities. The five states that do not specify requirements are California , the District of Columbia (there are not any disposal sites here), Iowa, Kansas, and Kentucky. In these 45 states, requirements are applied through the permit process and not through general regulations. A total of 30 states require a 2 foot compacted final cover of earthern material; 2 other states an offer alternative of 2 feet of earth or a membrane or 18 inches of earth covered by 6 inches of topsoil. Four states require 18 inches of earth covered by 6 inches of topsoil. One state allows 1 foot and 2 states allow 30 inches of final cover. Six states require 3 feet of final cover, although the cover may be 2 1/2 feet with 6 inches of topsoil. None of the final cover provisions are asbestos-specific. The final covers typically are graded and vegetated.

34 Although nearly all states have general provisions for the storage and/or transport of solid waste, 20 states have asbestos-specific provisions. These states are: Alaska, Arizona, Arkansas, California, Colorado, Connecticut, Illinois, Kansas, Louisiana, Maine, Maryland, Nebraska, New Jersey, New Mexico, New York, Ohio, Oklahoma, Oregon, South Carolina, and Virginia. The regulations vary widely. Two states require the vehicle to be lined with polyethylene sheeting. Two states require the transporter to notify the site prior to arrival; two require a waste manifest; one state requires the waste hauler to be State-registered and one state requires the hauler to be permitted for loads of 500 pounds or more. Two states require that asbestos waste be segregated from other waste during transport. One state requires a certified worker or supervisor to escort the vehicle to the disposal site. Nine states establish practices (e.g., locked dumpsters) or time/volume limits for temporary storage (store only to accumulate for disposal, limit of 500 55 gallon drums at the abatement site and 20 days at the disposal site, remove from abatement site within 5 days, store less than 20 cubic yards for 90 days or less).

35 No (zero) states were identified that have asbestos-specific provisions for waste disposal from demolition and renovation operations. Many states have regulations for demolition and renovation waste such as bricks, concrete, piping, etc that require cover materials primarily because of the potential fire hazard these materials may pose. However, asbestos-containing materials are typically not allowed in these landfills.

36 Fourteen of the 51 states have asbestos-specific rules governing vehicle covers. These states are: Alaska, Arkansas, California, Illinois, Kansas, Maryland, Massachusetts, Nebraska, New Mexico, New York, North Carolina, Oklahoma, Pennsylvania, and Virginia. Two states require that asbestos be transported in an enclosed cargo area or that the vehicle be equipped with a canvas cover. Four states require that asbestos be transported in an enclosed carrying compartment; one state requires openings to be securely closed, one state requires a tightly enclosed vehicle, and one state prohibits open vehicles. One state requires a vehicle cover. Two states require that asbestos be transported in an enclosed cargo area or that the cargo area (floors and walls) be completely enclosed with 6-mil plastic sheeting (one of these states requires sheeting only during freezing weather). Two states require the vehicle to be adequately enclosed or that the asbestos be in sealed drums or locked containers.

37 Five states were identified that have asbestos-specific decontamination requirements. These states are: Illinois, Maine, Nebraska, Oklahoma, and South Carolina. These regulations typically require that the cargo area be cleaned using wet methods or HEPA vacuuming. If polyethylene sheeting has been required, most of these states specify that it is to discarded along with contaminated cleaning materials and protective clothing at the waste disposal site. In one state, cleaning is not required if the cargo area has been lined with sheeting and no visible residue is present after its removal.

ATTACHMENT 1. DESCRIPTION OF REGULATORY ALTERNATIVES

INACTIVE SITES. This alternative would regulate all inactive disposal sites.

WORK PRACTICES 1. This alternative would require work practices in all cases and eliminate the no visible emissions limit as a compliance option for waste handling up to the point of transportation to the waste site.

WORK PRACTICES 2. This alternative would require work practices in all cases and eliminate the no visible emissions limit as a compliance option at active disposal sites.

INTERMEDIATE COVER. This alternative would require an intermediate cover between the time the site becomes inactive and the time final cover is applied.

COVER COMPACTION. This alternative would require waste to be covered before being compacted at active disposal sites.

FINAL COVER. This alternative would require a final cover of 36 inches at inactive disposal sites.

STORAGE/TRANSFER. This alternative would add requirements for offsite temporary storage and asbestos waste transfer facilities. Temporary storage would be limited to 180 days.

D & R WASTE. This alternative would revise methods for handling and disposing of bulk asbestos waste from demolition and renovation operations.

VEHICLE COVER. This alternative would require enclosed or covered waste transport vehicles.

VEHICLE DECONTAMINATION. This alternative would add decontamination provisions for waste hauling vehicles.

TABLE 3A. COMPARISON OF STATE REGULATIONS AND ALTERNATIVES FOR WASTE HANDLING, TRANSPORTATION, AND DISPOSAL

REGULATORY BASELINE	REGULATORY ALTERNATIVES									
	INACTIVE SITES	WORK PRACT. 1	WORK PRACT. 2	INTER-MEDIATE COVER	COVER COMPAC-TION	FINAL COVER	STORAGE/ TRANSFER	D & R WASTE	VEHICLE COVER	VEHICLE DECONTAM-INATION
Alabama	YES[1]	YES[2]	YES[3]	NO	YES[4]	YES[5]	NO	NO	NO	NO
Alaska	YES[6]	YES[7]	YES[8]	NO	NO	YES[9]	YES[10]	NO	YES[11]	NO
Arizona	NO	YES[12]	YES[13]	NO	YES[14]	YES[15]	YES[16]	NO	NO	NO
Arkansas	YES[17]	YES[18]	YES[19]	YES[20]	YES[21]	YES[22]	YES[23]	NO	YES[24]	NO
California	NO	YES[25]	YES[26]	NO	NO	NO	YES[27]	NO	YES[28]	NO
Colorado	YES[29]	YES[30]	YES[31]	YES[32]	NO	YES[33]	YES[34]	NO	NO	NO
Connecticut	YES[35]	YES[36]	YES[37]	YES[38]	NO	YES[39]	YES[40]	NO	NO	NO
Delaware	NO	YES[41]	YES[42]	YES[43]	NO	YES[44]	NO	NO	NO	NO
D. Columbia	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Florida	NO	NO	YES[45]	YES[46]	NO	YES[47]	NO	NO	NO	NO
Georgia	NO	YES[48]	YES[49]	YES[50]	NO	YES[51]	NO	NO	NO	NO
Hawaii	NO	YES[52]	NO	YES[53]	NO	YES[54]	NO	NO	NO	NO
Idaho	NO	NO	NO	YES[55]	NO	YES[56]	NO	NO	NO	NO
Illinois	NO	YES[57]	YES[58]	YES[59]	NO	YES[60]	YES[61]	NO	YES[62]	YES[63]
Indiana	NO	YES[64]	YES[65]	YES[66]	NO	YES[67]	NO	NO	NO	NO

REGULATORY BASELINE	REGULATORY ALTERNATIVES									
	INACTIVE SITES	WORK PRACT. 1	WORK PRACT. 2	INTER-MEDIATE COVER	COVER COMPAC-TION	FINAL COVER	STORAGE/ TRANSFER	D & R WASTE	VEHICLE COVER	VEHICLE DECONTAM-INATION
Iowa	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Kansas	NO	YES[68]	NO	NO	NO	NO	YES[69]	NO	YES[70]	NO
Kentucky	NO	YES[71]	YES[72]	NO	NO	NO	NO	NO	NO	NO
Louisiana	NO	YES[73]	NO	NO	NO	YES[74]	YES[75]	NO	NO	NO
Maine	NO	YES[76]	YES[77]	YES[78]	NO	YES[79]	YES[80]	YES[81]	NO	YES[82]
Maryland	NO	YES[83]	NO	YES[84]	NO	YES[85]	YES[86]	NO	YES[87]	NO
Massachusetts	NO	YES[88]	YES[89]	YES[90]	NO	YES[91]	NO	NO	YES[92]	NO
Michigan	NO	NO	YES[93]	YES[94]	NO	YES[95]	NO	NO	NO	NO
Minnesota	YES[96]	YES[97]	YES[98]	YES[99]	NO	YES[100]	NO	NO	NO	NO
Mississippi	NO	NO	NO	NO	NO	YES[101]	NO	NO	NO	NO
Missouri	YES[102]	NO	NO	YES[103]	NO	YES[104]	NO	NO	NO	NO
Montana	NO	NO	NO	NO	NO	YES[105]	NO	NO	NO	NO
Nebraska	YES[106]	YES[107]	NO	NO	NO	YES[108]	YES[109]	NO	YES[110]	YES[111]
Nevada	NO	YES[112]	NO	YES[113]	NO	YES[114]	NO	NO	NO	NO
New Hampshire	NO	YES[115]	NO	YES[116]	NO	YES[117]	NO	NO	NO	NO

REGULATORY BASELINE	REGULATORY ALTERNATIVES: INACTIVE SITES	WORK PRACT. 1	WORK PRACT. 2	INTER-MEDIATE COVER	COVER COMPAC-TION	FINAL COVER	STORAGE/ TRANSFER	D & R WASTE	VEHICLE COVER	VEHICLE DECONTAM-INATION
New Jersey	NO	YES[118]	YES[119]	NO	NO	YES[120]	YES[121]	NO	NO	NO
New Mexico	YES[122]	YES[123]	YES[124]	NO	YES[125]	YES[126]	YES[127]	NO	YES[128]	NO
New York	NO	YES[129]	YES[130]	YES[131]	NO	YES[132]	YES[133]	NO	YES[134]	NO
North Carolina	NO	YES[135]	YES[136]	YES[137]	NO	YES[138]	NO	NO	YES[139]	NO
North Dakota	NO	YES[140]	NO	NO	NO	YES[141]	NO	NO	NO	NO
Ohio	NO	NO	NO	YES[142]	NO	YES[143]	YES[144]	NO	NO	NO
Oklahoma	NO	YES[145]	YES[146]	YES[147]	NO	YES[148]	YES[149]	NO	YES[150]	YES[151]
Oregon	NO	YES[152]	YES[153]	NO	YES[154]	YES[155]	YES[156]	NO	NO	NO
Pennsylvania	NO	YES[157]	YES[158]	YES[159]	YES[160]	YES[161]	NO	NO	YES[162]	NO
Rhode Island	NO	YES[163]	YES[164]	YES[165]	NO	YES[166]	NO	NO	NO	NO
South Carolina	NO	YES[167]	YES[168]	YES[169]	NO	YES[170]	YES[171]	NO	NO	YES[172]
South Dakota	YES[173]	NO	NO	NO	NO	YES[174]	NO	NO	NO	NO
Tennessee	YES[175]	NO	NO	YES[176]	NO	YES[177]	NO	NO	NO	NO
Texas	NO	NO	YES[178]	NO	NO	YES[179]	NO	NO	NO	NO
Utah	YES[180]	YES[181]	YES[182]	NO	NO	YES[183]	NO	NO	NO	NO

REGULATORY BASELINE	REGULATORY ALTERNATIVES: INACTIVE SITES	WORK PRACT. 1	WORK PRACT. 2	INTER-MEDIATE COVER	COVER COMPAC-TION	FINAL COVER	STORAGE/ TRANSFER	D & R WASTE	VEHICLE COVER	VEHICLE DECONTAM-INATION
Virginia	YES[184]	YES[185]	YES[186]	NO	YES[187]	YES[188]	YES[189]	NO	YES[190]	NO
Vermont	NO	YES[191]	YES[192]	YES[193]	NO	YES[194]	NO	NO	NO	NO
Washington	NO	NO	NO	NO	NO	YES[195]	NO	NO	NO	NO
West Virginia	NO	NO	YES[196]	NO	YES[197]	YES[198]	NO	NO	NO	NO
Wisconsin	NO	NO	NO	YES[199]	NO	YES[200]	NO	NO	NO	NO
Wyoming	NO	NO	NO	YES[201]	NO	YES[202]	NO	NO	NO	NO

CODE: "YES" means the State rule contains a provision similar to or equivalent to the regulatory alternative. "NO" means the rule is similar to or equivalent to the existing Federal rules.

1 Discontinued unauthorized dumps must provide two feet or more compacted final cover within 30 days of completion of final grading and establish and maintain vegetative cover or equivalent. Closed facilities must be graded so that the slope of the two foot final cover is not more than 25 percent. If the slope is longer than 25 feet, horizontal terraces are required. Vegetative cover must be established and maintained. Provisions are not asbestos-specific (Section X).

2 Requires the use of impermeable containers that are air and water tight (Asbestos Specifications, Section 2.1.5). Also requires waste from encapsulation jobs to be packed in sealable plastic bags, 6 mil minimum thickness and placed in labeled container for transport. External surface of containers must be cleaned by wet sponging (Section 3.1). Abatement work may not begin until arrangements have been made at an acceptable site. Documentation regarding disposal must be provided to the building owner (Section 3.1.2).

3 Guidelines require that sealed plastic bags be dumped in the burial site unless broken or damaged. Broken bags must remain in a sealed drum and the entire drum buried. Uncontaminated drums may be recycled (Section 3.7). Section 13-4-.26(2) of the Alabama Solid Waste rules requires that if asbestos containers are places in a separate area of the landfill, the area must be clearly marked. Asbestos containers must be placed intact in a specially prepared place and covered with a minimum of 12 inches of earth at the end of each working day (Section 13-4-.26(2) of Solid Waste Rules).

4 Although cover materials are compacted, proper handling precautions must be taken to ensure that the containers are not ruptured; no machinery can be operated over uncovered containers (Solid Waste Rules, Section 13-4.26).

5 Final cover requirements are to meet Section 13-4-22(c). For asbestos sites, final grading in preparation for final cover must be done within 60 days for each filled area of 2 acres or more. Within 30 days of the grading, the final cover must be prepared for vegetative cover (13-4-.22(c)). Earth cover must be of a quality of be easily manageable and with a sufficient clay content to provide and adequate seal (Section 13-4-.22(d).

6 Alaska requires that the owner of a closed or abandoned asbestos waste disposal site maintain the integrity of the soil cover, slopes, vegetation, and drainage structures (Field Directive 2350). Alaska Solid Waste Management Regulations (18 AAC 80.087) require compliance with Field Directive 2350.

7 Containers may be barrels, drums, or double - 4 mil or thicker - plastic bags. Friable asbestos must be thoroughly wetted and containerized in leak-tight containers before burial. Packaging of nonfriable asbestos is not required, but may be appropriate to prevent the release of asbestos dust (Field Directive 2350).

8 The site permittee must be present at the site to supervise disposal; a log of asbestos source and quantity is required and visual inspection to assure that the asbestos is properly containerized is required. A separate fenced or barriered site in the landfill for disposal of friable and nonfriable asbestos with signs placed at 100 foot intervals also is required. The owner also must put a permanent marker or survey post at the location of the asbestos deposit; prepare drawings showing the location, update them annually, and file them with the State when the site is closed; and provide a record to subsequent landowners (Field Directive 2350).

9 Final cover of at least two feet must be applied within 90 days after the last waste deposit to areas that will not receive more waste within one year. Additional cover may be required in areas subject to excessive soil erosion or frost action (Field Directive 2350).

10 No permit is required for temporary storage, but the waste must be buried as soon as possible after it arrives at the landfill or be kept within a covered truck or building. Open air storage of containerized asbestos at the landfill is discouraged (Field Directive 2350).

11 Vehicles used for transport of containerized waste must have an enclosed carrying compartment or utilize a canvas covering sufficient to contain the transported waste, prevent damage to containers, and prevent fiber release.

12 Nonfriable asbestos may be handled as domestic refuse and construction debris. Friable asbestos requires wetting of material and placement in double 6 mil thick plastic bag or single 6 mil bag enclosed in leak-tight outer container. Pipes containing asbestos may be wrapped in 6 mil plastic to create a leak-tight container (Asbestos Waste Handling and Disposal Guidelines).

13 Landfill operator should inspect incoming loads for proper labeling and leak-tight packaging (Asbestos Waste Handling and Disposal Guidelines). Wastes must be covered with a least 6 inches of earth at the close of each operating day or within 24 hours of receipt; if waste is deposited in the active portion of the landfill, cover should be applied immediately (Asbestos Waste Handling and Disposal Guidelines).

14 Heavy compaction equipment can be driven over wastes after daily cover has been applied. During compaction, avoid uncovering wastes or tracking asbestos away from the trench (Asbestos Waste Handling and Disposal Guidelines).

15 A final cover of 30 inches of compacted earth must be applied once delivery of the wastes has ceased, unless the area will continue to be used for disposal of additional refuse using normal landfill procedures. The final cover should be properly graded and vegetated (Asbestos Waste Handling and Disposal Guidelines).

16 Waste haulers must notify landfill operator that incoming load contains asbestos (Asbestos Waste Handling and Disposal Guidelines).

17 Existing open dumps and other unpermitted disposal facilities must meet the same closure criteria as for permitted facilities (Section XVIII of Arkansas Solid Waste Code).

18 Friable asbestos materials must be placed in approved 6 mil plastic bags or double-bagged in 4 mil plastic bags or other more secure containers. Materials which include metal or other sharp objects must be placed in sealed metal drums. The disposal site operator must be notified of the approximate time of arrival and volume of asbestos material to be landfilled (Appendix A, Arkansas Solid Waste Code).

19 The landfill operator must be prepared to accept asbestos waste upon arrival. Wastes must be placed at the toe of the slope of the working face of the landfill or in a separate trench. Approved cover soil must be placed over the wastes upon receipt in a manner that will not rupture the container (Appendix A, Arkansas Solid Waste Code). Cover soil must not be less than a 6 inch layer after compaction.

20 An additional 6 inches of compacted cover must be applied within 48 hours (Appendix A, Arkansas Solid Waste Code).

21 Cover soil must be compacted, upon a sufficient amount of soil being placed over the asbestos material to prevent exposure of the containers during and after compaction (Appendix A, Arkansas Solid Waste Code).

22 For final cover, a compacted layer of at least 2 feet of material must be placed over the entire surface of all completed portions of the fill no longer than 60 days following final placement. The final cover must be graded and seeded and maintained for 2 years (Section XII-7(g), Arkansas Solid Waste Code).

23 Asbestos waste material may not be stored except as necessary to accumulate for transportation to an approved disposal site (Appendix A, Arkansas Solid Waste Code).

24 Asbestos waste must be transported in an enclosed conveyance unit to ensure that not material escapes either directly or indirectly.

25 In California, asbestos is classified as a hazardous waste; generators must have EPA identification number, prepare hazardous waste manifest for transportation, label and package asbestos as hazardous waste, and submit biennial and monthly reports.

26 Separate disposal section is required for asbestos. Containers must be maintained in an air-tight condition. (Rule 1403).

27 All vehicles, tanks, and containers must be designed and constructed and its contents so limited that under conditions normally incident to transportation, there will be no release to the environment. Transporter of hazardous waste must have EPA ID number and be registered with the State; a certificate of compliance may be placed on each vehicle, tank, or container which has passed inspection by the Highway Patrol. All vehicles, tanks, and containers must be free from leaks and all discharge. Transporter must clean up any discharge that occurs during transportation or take such action as may be required so that the waste no longer presents a hazard to human health or the environment (Chapter 30, Article 5).

28 Openings must be securely closed during transportation (Chapter 30, Article 5).

29 Operators stopping disposal of friable asbestos waste must submit report to State Department of Health demonstrating that all waste has been adequately covered and will not be disturbed and submit all available documents and information on location, quantity, and depth of the waste to the County Board of Commissioners (Regulations Pertaining to Solid Waste Disposal sites and Facilities, Section 8.3).

30 Asbestos waste must be soaked with amended water and kept wet until bagged for disposal. Disposal containers must be leak-tight and waterproof when sealed; disposable bags must be at least 6 mil polyethylene (Regulation No. 8, Section III(2)(i)-(j)). Regulations also require spill response procedures for releases due to breach of containment barrier; a spill is any amount of release over 50 linear feet or 32 square feet on other surfaces (Section II(3)(5)).

31 Operators of friable waste disposal areas must maintain permanent records of date and amount of waste received, location of disposal, quantity, and depth of burial Friable waste may not disposed of within 25 feet of the property line; containers must not rupture; structurally rigid containers must be disposed of within 72 hours of receipt or termination of storage and all other containers must be disposed of within 24 hours of receipt or termination of storage; no additional friable material can be received if the site receives 250 cubic yards of friable asbestos within 30 days. Friable asbestos must be sealed in at least two 6 mil, leak-tight plastic bags. Friable and nonfriable waste must have at least 6 inches of soil over the working surface at the end of the operating day (Regulations Pertaining to Solid Waste Disposal Sites and Facilities, Section 8).

32 Friable and nonfriable waste must have at least one foot of soil over disposed solid wastes in areas left temporarily unused for at least one month, but not finally closed (Regulations Pertaining to Solid Waste Disposal Sites and Facilities, Section 8).

33 Friable and nonfriable waste must have at least 2 feet of soil over the entire fill surface at final closure (Regulations Pertaining to Solid Waste Disposal and Facilities, Section 8).

34 Temporary storage at an abatement site prior to disposal is limited to 500 55-gallon barrels; storage is permitted only on property owned or operated by the contractor or building owner (Regulation No. 8, Section III.3.8). At the disposal site, asbestos must be stored in a segregated location for no more than 20 days (Regulations Pertaining to Solid Waste Disposal Sites and Facilities, Section 8.2). No friable asbestos waste can be accepted for transport unless prepared and received, tightly-sealed in at least two 6 mil leak-tight plastic bags or in a wrapping or other covering deemed equivalent (Regulations Pertaining to Solid Waste Disposal Sites and Facilities, Section 8.3).

35 Closure requirements include provisions for 2 foot final cover that is vegetated and maintained (Standards for Asbestos Disposal, Section 22a-209-13).

36 All asbestos waste must be adequately wetted with an amended water solution and placed in leak-tight containers (Connecticut Administrative Regulations 19a-332-5(11)).

37 Asbestos must be segregated in a separate cell apart from the active potion of the landfill. Asbestos must be deposited at the base of the working area of the cell without breaking or otherwise opening the containers and be covered immediately with 9 inches of suitable cover material (i.e., earth or other mixed waste) (Section 22a-909-7).

38 Intermediate cover of 1 foot of earth must be applied and maintained on surfaces not to receive additional waste within 9 months (Section 22a-909-7).

39 Final cover of 2 feet of earth material must be applied upon completion and vegetated in the next planting season; cover integrity must be constantly monitored particularly after each wind or rain storm and replaced immediately if eroded (Section 22a-909-7).

40 Asbestos must be packaged in impermeable dust-tight containers such as heavy duty 6 mil plastic bags or sealed pack drums for transport. Asbestos must be transported separately from other waste materials (Section 22a-209-(i)(2)(A)).

41 Deposit all waste, sealing tape, plastic, mopheads, sponges, filters, and disposable clothing in a sealed container. (Regulation 21). Notify Solid Waste Authority 24 hours in advance of disposal with the amount of anticipated waste to be disposed (unwritten policy).

42 Nonasbestos-specific solid waste disposal standards require facility operator of sanitary landfill to maintain records of type of waste received quarterly (including asbestos-containing waste) which require State approval prior to being landfilled. Six inch daily cover required. (Solid Waste Disposal Regulations, Section 5(I)).

43 Nonasbestos-specific standard requires intermediate cover of at least six inches of suitable cover material for areas that receive daily cover and are not expected to receive additional solid waste or a capping system within six months (Section 5(I)).

44 Nonasbestos-specific standard for final cover for all facilities requires a 20 mil geomembrane cover underlain by a geotextile, or 24 inches of clay with meeting hydraulic conductivity specifications, or an approved alternative of 18 inches of soil with an additional 6 inches of topsoil with a vegetative cover. This is applicable to sanitary and industrial facilities (Section 5(I)).

45 Florida adopts asbestos NESHAP disposal requirements (covered daily with dust suppressant or 6 inches of nonasbestos material or dispose of in area with warning signs and fences); a supplemental provision provides that asbestos disposed of at a Class I or Class II landfill must meet requirements for sanitary landfill (Resource Recovery and Management Rules, DER 1985, Section 17-7.060. Sanitary landfill rules require a 6 inch initial cover at the end of the day except for the working face which may be left uncovered if solid waste will be placed on the working face within 18 hours (DER 1985, Section 17-7-050).

46 An intermediate cover of 1 foot of compacted earth must be applied within 7 days of the cell completion at all landfills if final cover or additional lift is not to be applied within 180 days of cell completion (Section 17-7-050).

47 At completion of the site, 1 foot final cover seeded or vegetated is required (Section 17-7-050).

48 Contractor must complete disposal manifest form (Chapter 391-3-14-02).

49 Landfill operator must complete and sign disposal manifest form (Chapter 391-3-14-02). Nonasbestos-specific solid waste management rules require that unless a variance is received, a uniform compacted layer of clean earth cover at least 6 inches in depth must be placed over all exposed waste by the end of each day, or more frequently if required by State. In no case may waste be left uncovered for more than 24 hours (391-3-4-.07(c)).

50 Nonasbestos specific rules require a uniform compacted layer of clean earth cover at least 1 foot in depth must be placed over each portion of any intermediate lift following completion of that lift (391-3-4-.07(d)).

51 Nonasbestos specific rules require final cover of clean earth not less than 2 feet in depth and a vegetative cover placed over final lift no later than 1 month after placement of waste within that lift (391-3-4-.07(e).

52 Nonmandatory asbestos disposal guidelines require wetting with water or surfactant prior to packaging in disposable containers to include 6 mil plastic bags, plastic lined cardboard or metal containers. Friable material must be double-bagged in 6 mil plastic bags. Landfill must be notified 1 day before delivery. Mass dumping prohibited. Daily cover of 6 inches per NESHAP required. (Section 12-2-2-13, Appendix G).

53 Nonasbestos-specific solid waste regulations require 1 foot of intermediate cover (Section 11-58-4)

54 Nonasbestos-specific solid waste regulations require 2 foot final cover (Section 11-58-4).

55 Nonasbestos-specific solid waste regulations require an intermediate cover compacted to depth of 1 foot in completed areas where another lift will be placed on top within 1 year; areas left longer than 1 year require 2 feet of compacted cover (Solid Waste Rules and Standards, Section 01.6008.12)

56 Nonasbestos specific solid waste regulations require 2 foot final cover completed within 1 week after placement of waste in the final lift (Section 01.6008.12).

57 For removal projects in schools, 6 mil polyethylene bags or drums shall be sealed when full. Double bagging must be used when polyethylene bags are used. Bags shall not be overfilled and shall be sealed to prevent accidental opening and leakage by tying tops in an overhand knot or by taping in a gooseneck fashion; bags shall not be sealed with wire or cord. Bags may be placed in drums for staging and transportation to the landfill. Bags shall be decontaminated on exterior surfaces by wet cleaning before being placed in clean drums and sealed with locking ring tops. Large components shall be wrapped in 2 layers of 6 mil polyethylene sheeting and secured with tape. Asbestos containing materials with sharp edges (e.g., nails, metal lath, tin sheeting) which may tear bags shall be placed in drums for disposal (Section 855.190). All containerized waste must be removed from work area and holding area on a daily basis (Section 855.220).

58 Nonasbestos specific rules for sanitary landfills (title 35, Subtitle B, Section 807.303 and .305) require that all refuse be deposited into the toe of the fill or the bottom of the trench, be spread and compacted. A 6-inch cover of suitable material is required at the end of each day. Sanitary landfill must keep daily, quarterly, and supplemental waste records (Se3ction 858.202).

Disposal requirements for school projects (Section 855.240) provide that upon reaching the landfill, trucks shall approach the dump location as closely as possible for unloading asbestos waste. Bags, drums, and components must be inspected when off-loaded and any material in damaged containers repacked in empty drums of bags. Waste containers must be placed on the ground at the site, not pushed or thrown out of trucks. Workers unloading containers at the disposal site must wear protective equipment.

59 An intermediate cover of at least 12 inches of suitable material is required on all surfaces where no additional refuse will be deposited within 60 days (Section 807.305).

60 A final cover not less than 2 feet must be placed over the entire surface of each portion of the entire lift within 60 days of placing waste in the final lift (Section 807.305).

61 All asbestos waste must be wetted before loading into trucks, other vehicles, or containers. During transport, waste must be enclosed or covered so as to prevent dust dispersion (Title 35, Subtitle B, Section 228). Waste sludge containing asbestos collected from settling ponds at manufacturing plants must be enclosed during transport (Section 228.156).

In school abatement jobs, contractor may temporarily store waste in large metal, locked dumpsters or an enclosed truck at the abatement site. At conclusion of the project, all materials must be removed and transported to disposal site (Section 855.220). Temporary storage at a location other than the abatement project is prohibited. For transport of waste from school projects, drums must be placed on level surfaces in the cargo area and packed tightly to prevent shifting and tipping. Large structural components shall not be placed on top of bags and must be secured to prevent shifting. Large metal dumpsters or enclosed area of truck must have metal doors or metal tops that can be closed and locked; unbagged material and nonasbestos waste shall not be placed in these containers. Bags shall be placed, not thrown into these containers to avoid splitting (Section 855.240).

62 Asbestos waste from school projects (drums, bags, and wrapped components) must be loaded into an enclosed truck for transportation; cargo areas must be locked when unattended. (Title 77, Chapter I, Subchapter p, Section 855.240).

63 Transportation rules for asbestos waste from school projects require the enclosed cargo area of the truck to be free from debris and lined with 6 mil polyethylene sheeting to prevent contamination from leaking or spilled containers. Floor sheeting shall be installed first and extend up the side walls; wall sheeting shall overlapp by 6 inches and be taped into place (Title 77, Chapter I, Subchapter p, Section 855.240). Following removal of all containerized waste, the cargo area shall be decontaminated using HEPA vacuums and/or wet methods. Polyethylene sheeting shall be removed and discarded in bags or drums along with contaminated cleaning materials and protective clothing (Section 855.805).

64 Packaging requirements for disposal include sufficient wetting to prevent airborne releases and packaging in 6 mil plastic bags or wrapping in 6 mil plastic. Each load must be accompanied by the waste notification form. Disposal facility must receive 24 hour notice of intent to dispose (329 IAC 2-21).

65 Asbestos classified as a special waste under solid waste management rules, except baghouse collection sludges or dust, floor tiles and asphalt-based siding and floor materials (329 IAC 2-21-5). Waste must be covered immediately with soil or solid waste; there must be no direct physical contact between waste and heavy equipment during disposal/cover operations. General solid waste management rules require 6 inches cover over all exposed waste by the end of the operating day regardless of weather conditions or within 24 hours for facilities that are open continuously.

66 Intermediate cover of at least 1 foot over any point in the fill which has not received waste for 90 days or more (329 IAC 2-14-13).

67 Final cover of at least 2 feet within 180 days of receiving its final waste volume with an additional 6 inches of topsoil to establish vegetation (IAC 2-14-13).

68 All friable asbestos waste must be placed in tightly sealed containers in wet condition before it is removed from the work area. Containers shall be double bagged in not less than 6 mil thick bags unless the waste contains rigid or heavy objects likely to tear the bags. If bag damage is likely, the waste must be placed in fiber or metal containers equipped with a plastic bag liner and tight fitting lid. Large sections of structural items may be tightly wrapped in a double layer of 6 mil sheeting if they can not be placed in containers. All exposed surfaces must be in a wet condition when an item is wrapped. The exterior surface of containers or wrapped objects must be cleaned free of visible residue. (Section 650-3406).

69 Wastes must be removed from the project area to the approved disposal site within 5 days of completion of the work (Disposal of Asbestos Procedures).

70 Wastes must be transported in vehicles that have completed enclosed cargo areas or cargo areas (floors and walls)are to be completely covered with 6 mil plastic sheeting in freezing weather (Disposal of Asbestos Procedures).

71 Asbestos must be thoroughly wetted and either double-bagged in 6 mil plastic bags and placed into rigid containers or for large components, wrapped in 2 layers of polyethylene sheeting (401 KAR 63:042, Section 4).

72 Asbestos is treated as a special waste; it may be buried with other waste provided it is placed in the bottom of the cell and requires an immediate 2 foot cover of garbage or soil Disposal in a separate pit must be 4 feet below existing grade with at least 4 feet of soil placed over the containers .

73 Owner operator must complete waste verification form and provide it to transporter prior to off-site shipment (Section 81.3, Subpart F).

74 Final cover of 2 feet required (Section 81.6).

75 Waste transporter must provide completed waste verification form to solid waste disposal site owner/operator (Section 81.3, Subpart F).

76 Asbestos considered a special waste under solid waste management rules; requirements apply to friable, nonfriable, and asbestos-contaminated wastes (Section 405.4). Before storage, transport, or disposal, all asbestos waste material shall be in a nonfriable condition or adequately wetted and containerized in 2 layers of leak-tight plastic, each layer a minimum thickness of 6 mil.

77 Waste must be in a wet or nonfriable condition when delivered to the disposal site. The disposal site must be permanently identified (permanently marked if not at a licensed landfill or recorded in the operating plan at a licensed landfill). Waste must be separated from other solid waste. No emissions over 0.1 f/cc at any waste storage or disposal site. At the storage or disposal site, all containers must be inspected when off-loaded ; material in damaged containers shall be repacked to meet disposal requirements. Upon reaching the friable asbestos disposal site, trucks shall approach the storage or disposal area as closely as possible for unloading of the waste; containers shall be placed on the ground, not pushed or thrown from the truck. Personnel offloading the containers at the storage or disposal site must wear protective equipment. Six inches of compacted nonasbestos cover must be applied every 24 hours during the disposal operation or at the end of each working day. Nonfriable asbestos shall not be shredded, crushed, or subject to volume reduction prior to disposal.

78 General landfill rules require intermediate cover of 1 foot over any areas of the landfill that will be inactive for more than 4 weeks but less than 6 months. Temporary seeding or mulch must be applied for erosion control (Chapter 401, Section 6.8).

79 Final cover requires 6 inches of seeded topsoil upon 18 inches of clay or other similar material that can achieve a maximum permeability of 5×10^{-7} cm/sec., shall be shaped to protect against erosion by surface runoff and shall be applied within 30 days of the last placement of waste materials (Chapter 405, Section 4).

80 Storage of friable asbestos must occur at a licensed landfill and requires review and approval: storage of nonfriable waste from construction or demolition activity shall occur in an approved designated portion of a licensed landfill. All handling precautions described in Footnote 101 also apply to storage facilities. In addition, storage shall occur at the facility from which it originated or at an approved storage or disposal site. Friable asbestos must be stored in a locked, fiber-tight, and impact resistant enclosure sufficient to prevent unaided human entry. All containerized waste must be placed in leak-tight metal containers when stored outside. The perimeter of the storage site must be fenced. Nonfriable asbestos shall be adequately wetted during storage and covered with a tarp or 6 mil plastic sheet during storage and transport. The cover shall be sufficiently secured to prevent the direct effect of wind or evaporation during during storage and transport (Chapter 405, Section 4).

81 Nonfriable a/c piping used in water distribution systems and wastewater collection systems does not require disposal in a demolition debris landfill under the following conditions: (1) it is thoroughly wetted during any cutting, grinding, or breaking, (2) it remains in its original trench and remains buried or is reburied at its original trench depth or deeper immediately upon completion of installation or abandonment, or (3) it is removed to a site other than a licensed demolition debris landfill for immediate burial of 18 inches and 6 inches of seeded topsoil. (Chapter 405, Section 4). Construction/demolition landfills that are mixed with other solid or liquid waste are regulated as municipal waste, compost, hazardous waste, or special waste (i.e., asbestos), as appropriate (Chapter 404, Section 1).

82 Following removal of all containerized waste, the truck cargo area shall be decontaminated using HEPA vacuums or approved wet methods. Polyethylene sheeting shall be removed and discarded along with contaminated cleaning materials and protective clothing once daily (Chapter 405, Section 4).

83 All asbestos waste, including sealing tape, plastic sheeting, mop heads, sponges, filters, and disposable clothing, must be put in plastic bags at least 6 mil thick and sealed. Large structural components that can not be put in bags or containers must be wrapped in 6 mil plastic and taped closed. (Code of Maryland, 26:11:21.08)

84 Nonasbestos-specific solid waste rules require 1 foot intermediate cover of clean earth over each portion of a lift no later than 1 month following of that lift (Section .10D).

85 Nonasbestos specific solid waste rules require 2 foot final cover of earthern material over final lift within 90 days of completion of the lift.

86 Interim storage by contractor allowed if: (1) contractor obtains storage license, (2) less than 20 cubic yards is stored, (3) waste is enclosed in rigid containers maintained in a secure area, (4) storage is less than 90 days, and (5) application is filed and approved by Department of Health. At project sites not subject to NESHAP, waste must be removed within 24 hours of completing renovation, demolition, or encapsulation; at sites subject to NESHAP, waste must be removed within 7 days. After removing waste from project site, dispose of at authorized facility or comply with interim storage requirements. (Code of Maryland 21:11:21.08).

87 Asbestos waste can not be transported in an open vehicle (Code of Maryland 26:11:21.08).

88 Asbestos waste may not accumulate in work area but shall be containerized in a timely fashion. Waste and contaminated debris without sharp edges shall be double bagged (6 mil minimum for each plastic bag); waste and debris with sharp edges must be containerized in metal, plastic, or fiber drums with locking lids. Large components shall be wrapped in at least 2 layers of 6 mil thick plastic sheeting and securely sealed (453 CMR 6.14).

89 Asbestos must be disposed of at an approved sanitary landfill special waste site (310 CMR 7.15(e)). Nonasbestos specific solid waste regulations require special wastes be disposed of in a separate area in the landfill (Section 19.16). A daily cover of 6 inches before the end of each working day is required (Section 19.15).

90 Nonasbestos specific solid waste regulations require intermediate cover on top and sides of lift (depth not specified) within 1 month after placing refuse in that portion of the lift; the cover must be impervious to prevent the percolation of surface or rain water and shall be at a slope of not less than 2 percent (Section 19.15).

91 Nonasbestos specific solid waste regulations require final cover of at least 2 feet, graded at a slope of not less than 2 percent; cover must be in place within 1 month following completion of the section (Section 19.15).

92 Transport of asbestos waste must be in covered vehicles or locked containers (453 CMR 6.14).

93 Asbestos may be disposed of only at a Class II landfill and must be segregated from other waste (Rule 299.43.6). Nonasbestos specific solid waste management rules require a 6 cover of suitable material applied by the end of the operating day. All daily cover depths must be continually maintained (Rule 299.4316).

94 Nonasbestos specific solid waste rules require an intermediate cover of 1 foot, which may include the 6 inch daily cover, placed on the surface of any lift that will be exposed for 3 months or more before any additional lifts are constructed (Rule 299.4316).

95 Final cover must be placed over the entire surface of each portion of the final lift within 3 months following the placement of waste within that portion; final cover depths must be maintained for 5 years. Final cover must be seeded and stabilized as soon as practical after placement of final cover (Rule 299.4316). Final cover must be at least 2 feet compacted to not less than 90 percent of maximum dry density as determined by the modified proctor test (ASTM D1557-70). Cover material also must be compacted at a moisture content not dryer 2 percentage points below not wetter than 5 percentage points above optimum moisture content as determined by the modified proctor test (Rule 299.4305).

96 Nonasbestos specific solid waste regulations require that abandoned sites and dumps be closed according to rules; refuse must be compacted and covered with at least 2 feet of compacted earth material and the cover graded and seeded for vegetation. A detailed description of the site, including a plat, must be filed with the county recorder. (Rule 7035.2500).

97 Asbestos containing material must be removed in small sections and placed in containers while wet. Material must not be allowed to dry. Structural components must be thoroughly wetted and sealed in 6 mil polyethylene sheeting or comparable material before disposal. Metal or fiber drums with locking rings must be used for disposal of wastes that contain sharp edges, unless the sharp edges can be covered or blunted (Rule 7005.1616, Subpart 4).

98 Nonasbestos specific solid waste rules require the facility to develop a plan for management of industrial solid waste, including asbestos (rule 7035.2535). A six inch cover of suitable material must be applied after each day's operation (Rule 7035.1700, Subpart C).

99 An intermediate cover of at least 1 foot must be applied to all fill surfaces where no additional waste will be applied within 30 days (Rule 7035.2815, Subpart 6).

100 The final cover must be designed and constructed to contain or reject at least 90 percent of precipitation. The cover system must consist of a barrier layer (2 feet thick if soil or amended soils or a synthetic membrane), a drainage layer (6 inches), and a top layer (18 inches thick, of which at least 6 inches is topsoil). (Rule 7031.2815, Subpart 6).

101 Final cover of at least 2 feet, the top 6 inches of which is topsoil), required for each completed section of the fill within 30 days of completion (Regulation PC/S-1, Section D).

102 Nonasbestos specific solid waste rules require that unpermitted facilities and open dumps be closed; actions may require removal of wastes unlawfully deposited, compacting wastes, covering waste, and recording the existence of the site with the recorder of deeds (10 CRS 80.2.030).

103 Nonasbestos specific solid waste rules require intermediate cover of at least 1 foot on filled areas that are idle for more than 60 days (10 CRS 80-3.010(13).

104 Nonasbestos specific solid waste rules required final cover to be increased to a total thickness of 2 feet (synthetic membrane can be used as an alternative) with an additional 1 foot of soil that is graded, sloped, and vegetated (10 CRS 80-3.010(13).

105 Nonasbestos specific solid waste rules require Class II sites to provide at least 2 feet of approved earth cover within 1 week after final deposit of waste at any portion of the site (16.14.521).

106 Nonasbestos specific solid waste management rules require that before any site is abandoned, all exposed refuse must be covered with suitable cover to an approximate compacted depth of 2 feet (Chapter 6, Section 022).

107 Asbestos waste must be maintained in a wet condition and immediately placed in tightly sealed containers. Use plastic bags at least 6 mil thick. Rigid or heavy objects likely to tear bags must be placed in fiber or metal containers lined with plastic bags not less than 6 mil thick and that have tightly fitting lids which can be fastened firmly in position. Large structural units, such as pipe or ductwork, that have been removed with asbestos left in place and that can not be placed in contained must be tightly wrapped in 2 layers of plastic sheeting at least 6 mil thick. Clean the exterior surface of each container or individually wrapped object free of all visible residue by wet cleaning before removing from the work area. Handle each container carefully, if breakage occurs or becomes unable to completely contain the waste, transfer waste immediately to another container, saturate with water, and clean contaminated area free of all visible residue.

108 Final compacted layer of 2 feet of earth, graded and grassed (Section 013).

109 Store any asbestos waste removed from work area but not yet delivered to any approved disposal site in a secure holding facility or location accessible only to persons certified in an asbestos occupation. Waste must be transported in vehicles operated or escorted by a certified asbestos worker or supervisor. Contractor retains responsibility for waste until it is accepted at licensed and approved asbestos waste disposal site (Title 178, Chapter 122, Section 020).

110 Use vehicles with completely enclosed cargo areas or completely enclose cargo area with 2 layers of plastic sheeting not less than 6 mil thick (Section 020).

111 Immediately clean vehicles cargo area free of all visible residue using a HEPA filtered vacuum or by wet cleaning methods after waste has been deposited at an approved asbestos waste disposal site. Cleaning is not required if cargo area has been lined with a disposable 6 mil plastic lining and the cargo area is free from all visible residue after the liner is removed (Section 020).

112 Equipment, materials, and supplies must be decontaminated and cleaned prior to removal or sealed in an airtight container and wrapped in 2 layers of 6 mil polyethylene sheeting. Sections of insulated pipe or other objects to be disposed of intact may be transported to the disposal site without the removal of any material containing asbestos if it is sealed in an airtight container or 2 layers of 6 mil polyethylene sheeting (NAC 618, Section 69).

113 Nonasbestos specific solid waste management rules require Class I sanitary landfills to apply intermediate cover of 12 inches of suitable material placed daily on all surfaces of the fill except those where operations will continue the following day; the integrity of the daily and intermediate cover must be maintained until final cover is applied (Section 444.688). No intermediate cover is required for Class II or Class III landfills.

114 Nonasbestos specific solid waste management rules require final cover of 2 feet of suitable material must be applied within 30 days of lift completion and graded 2-4 percent to drain surface runoff water required for Class I and II landfills (Section 444.688 and 444.716); 2 foot cover must be applied within 90 days of completion at at Class III landfill (Section 444.738).

115 Asbestos shall be maintained wet during and after removal until placed into leak-tight containers for disposal. Double impermeable bags of at least 6 mil thickness and which may be securely sealed shall be used; large structural components may be removed intact when wrapped air-tight in 2 layers of 6 mil sheeting secured with tape (ENV-C 404.02).

116 Nonasbestos specific solid waste management rules require a 12 inch intermediate cover when the working face is not active (i.e., more than 1 month without additional layers of refuse) sloped between 2 and 15 percent (He-P1901.05(b)).

117 Nonasbestos specific solid waste management rules require a 12 inch final cover on all portions of the landfill that will not be used within the next 12 months and seeded for vegetation (He-P1901.05(b)).

118 All asbestos waste shall be picked up while wet and place in 6 mil plastic bags, double bagged, and securely sealed by knotting he bag or sealing with high quality tape; all contaminated clothing cleaning rags, mops, etc. must be treated as waste. (NJAC 5:23-8:11(b). Contaminated material containing sharp edged items shall be bagged or singly bagged and placed in temporary fiber drums. Containers shall be washed with amended water or a removal encapsulant and have all exterior particulate matter removed before removal from the contaminated work area (NJAC 5:23-8:10).

119 Asbestos specific rules for sanitary landfills require disposal in a separate area of the landfill or special procedures for burial in the working face of the landfill; use of the trench method is recommended. Disposal must occur immediately upon acceptance. Landfill operator must maintain a record of disposal. After unloading, the waste shall be immediately covered with a minimum of 3 feet of soil (NJAC 7:26-2A).

120 Asbestos specific rules for sanitary landfills require a final cover of at least 3 feet graded to facilitate runoff away from the area and seeded and maintained to prevent exposure and erosion (NJAC 7:26-2A)

121 Waste hauler must notify Department of Environmental Protection at least 10 days before intended date of disposal (NJAC 7:26-2.12). Transporter shall not accept drummed waste in damaged, rusted, or leaking containers (NJAC 7:26:2A).

122 Existing sites that no longer accept asbestos waste must file notification of closure and file a closure plan (Asbestos Management Regulations, EIB/AMR-1, Section 2-2).

123 Asbestos is classified as a hazardous waste and must be treated before disposal or disposed of only at permitted facilities. Asbestos-specific regulations require disposal at Class A (sanitary landfills serving 3,000 or more) or Class D (industrial onsite operations). Waste can not be accepted for transportation unless properly containerized. Waste must be packed in 6 mil plastic bags, sealed to be leak-proof, and the amount of air space in the bag minimized. Slurries must be in leak proof drums if too heavy for bags. Pipe and other facility components must be wrapped in 6 mil plastic (Solid Waste Management Regulations, Part IV).

124 Asbestos-specific regulations require operator to inspect loads for proper containerization. If waste is not properly containerized, operator must wet prior to unloading, rinse out the truck, and immediately cover. For disposal, a separate trench must be used; the trench must be as narrow as possible and aligned perpendicular to the prevailing winds. Containerized waste must be covered within 18 hours with a minimum of 6 inches of nonwaste containing materials (Section IV). Operator also must inspect facility for malfunctions and deterioration, errors, and discharges that may cause, or may lead to releases and correct these problems and develop a written schedule for inspections (Asbestos Management Regulations, Section 1-4)

125 The operator shall not compact waste until 6 inch cover has been applied; final cover is compacted (Section IV).

126 A final cover of 30 inches of compacted nonwaste containing material shall be applied to provide a 36 inches final cover (Section IV).

127 Transporter can not accept waste unless properly containerized and must transport as soon as possible after acceptance. Loading and unloading must be done in a manner to avoid breaking of containers. No vehicle that uses compactors may be used to transport asbestos; vacuum trucks must be inspected to insure that liquid is not leaking. Transporter also shall notify landfill operator that the load contains asbestos (Section IV).

128 Vehicles used for transport of containerized waste must have enclosed carrying compartments; all surfaces of vehicles and equipment shall be maintained free from accumulation of dust and waste (Section IV).

129 Asbestos material shall be wetted frequently with amended water and placed in 6-mil plastic bags; large components removed intact shall be wrapped in 2 layers of 6 mil sheeting, secured and made air-tight with tape. Material with sharp-edged components that may tear bags or sheeting shall be placed in hardwall containers and sealed air tight (Section 56-12.1) In New York City, abandonment of waste is prohibited (Section 8180).

130 Asbestos-specific regulations require landfill operator to maintain record of location of disposal. Contaminated drums must be emptied, crushed, and disposed of with other asbestos waste; uncontaminated drums may be reused. Preferred method of disposal is a separate trench with 5 feet groundwater separation, back filled with at least 3 feet of refuse to bridge asbestos bags and to buffer between asbestos and tracks of compaction equipment; at least 6 inches of daily cover is required. With the nontrench method, the asbestos is placed at the bottom of the working face with a 6 inch daily cover (SWMG 3.3).

131 With trench method, at least 1 foot of soil (in addition to 6 inch daily cover) is required; with nontrench method, waste must be covered by at least 3 feet of refuse prior to compaction (in addition to 6 inch daily cover) (SWMG 3.3). The intermediate cover must be applied where no additional solid waste will be deposited within 30 days (360.8(b)(1)).

132 A final cover must be applied whenever an additional lift is not be be applied within 1 year, within 90 days for any area attaining final elevation , or to an entire landfill which has been denied a permit or terminates operation; the thickness of the cover is not specified (360.8(b)(1)).

133 Waste haulers of 500 pounds or more must have permit Part 364.2) and must remain with the vehicle when it is being filled or unloaded. Transporter also must notify landfill operator of intent to disposal, the date of disposal, and the amount (Solid Waste Management Guidelines, 3.3). In New York City, the waste hauler must examine leak-tight containers every 24 hours, carry spare leak-tight containers and amended water , and separate asbestos and other waste. Also must complete waste hauler manifest (NYC Department of Sanitation Regulations, Section VI). In New York City, a permit is required to store more than 50 cubic yards.

134 In New York City, waste haulers must tightly enclose vehicles containing asbestos waste (Section VI).

135 All loose asbestos material removed in the work space shall be bagged, sealed, and properly labeled before the break ends or the end of the shift (Specifications, IV(D)). All material shall be double bagged; each bag shall be individually sealed and placed in containers suitable for transport; containers must be nonporous steel or plastic drums. The outside bag and container must be clean before leaving the loading area. Contaminated materials such as panels, lathe, pipe, etc. may be wrapped in at least two layers of plastic and properly protected from perforation of the plastic as an alternative to plastic bags (Specifications, IV(D)). These provisions apply only to state-owned building projects.

136 Nonasbestos specific solid waste management rules require a 6 inch daily cover (.0505). Asbestos specific provision require that asbestos may be disposed of separate from other wastes in the working face or in a separate area, in either case, in virgin soil. Separate areas must be clearly marked. Waste must be covered immediately; fencing and diking is required to shelter asbestos waste from wind (.0505-10 and 11). Damaged bags must be left in containers for burial; uncontaminated drums may be recycled (Specifications, IV(E)).

137 Nonasbestos specific solid waste management rules rules require a 1 foot intermediate cover on areas that will not have additional waste deposited for 1 year or more (.0505).

138 Nonasbestos specific solid waste management rules require that after completion of disposal operations or revocation of a permit, a final cover of at least 2 feet of suitable earth must be applied (.0505).

139 Truck covers and work practices must assure that no asbestos becomes airborne during transport of waste from state owned building projects (Specifications, IV(D)).

140 Contractor must submit disposal manifest.

141 All completed disposal sites must be covered with at least 24 inches of compacted earth, free from cracks and extrusions of refuse (Administrative Code, 33-20-05-01).

142 Nonasbestos specific solid waste management regulations require a 1 foot intermediate cover applied by the end of the working day to all areas where additional materials will be deposited 30 days or more after completion of the cell (3745-27-09).

143 Nonasbestos specific solid waste management regulations require a final cover so that all waste materials are covered by at least 2 feet (3745-27-09).

144 All loads must be accompanied by hazardous waste manifest (no citation).

145 Containers (6 mil polyethylene bags or drums) shall be sealed when full and not overfilled. Containers shall be securely sealed by tying tops in an overhand knot or by taping in a gooseneck fashion; containers shall not be sealed with wire or cord. Friable asbestos must be double bagged or single bagged and placed in disposal drum. Bags shall be decontaminated on exterior surfaces by wet cleaning and HEPA vacuuming before being placed in clean drums. Large components removed intact shall be wrapped in 2 layers of 6 mil polyethylene sheeting secured with tape. Waste with sharp edges that may tear sheeting or bags shall be placed in drums or boxes wrapped in a minimum of 2 layers of 6 mil sheeting, secured with tape (Rule 9.05.07). The contractor must notify the landfill operator of the approximate time of arrival and volume of waste to be disposed.

146 Waste containers must be placed on the ground at the disposal site, not pushed or thrown out of trucks. Bags, drums, and components must be examined as they are off-loaded; material in damaged containers must be repacked. Trucks are to approach the dump location as closely as possible for unloading (Rule 9.09.05). Landfill operators must complete asbestos disposal reporting form and forward it to Department of Health. Landfill must designated a separate area for waste disposal; a separate trench must be used. Cover soil must be placed over the waste upon receipt (Summary of Procedures for Friable Asbestos Waste). Nonasbestos specific solid waste management rules require at least 6 inches of initial cover (3.0.11).

147 Nonasbestos specific solid waste management rules require an additional 6 inches of earthern material must be placed on areas where final cover or additional refuse will not be placed within 2 weeks (3.0.12)

148 Nonasbestos specific solid waste management rules require a final cover of 2.5 feet over the entire surface of final lift. An additional 6 inches of cover capable of sustaining plant growth also is required. The earthern cover shall be compacted in layers no more than 8 inches thick and shall be placed over the surface within 1 week following placement of the final layers of refuse in that portion (3.0.13).

149 Asbestos waste can not be stored at the landfill except as may be needed for accumulation prior to disposal; storage must be in a closed and controlled area to prevent rupture of the containers (Summary of Procedures for Disposal of Friable Asbestos). Waste haulers must be licensed as abatement contractors (Rule 5.01.013) and must furnish the Department of Health with a disposal agreement with an approved landfill each year (Rule 7.6). The cargo area of the truck must be free of debris and lined with 6 mil polyethylene sheeting to prevent contamination from leaking or spilled containers; floor sheeting must be installed and extend up the sidewalls and wall sheeting overlapped and taped in place. (Rule 9.09.03). Drums must be secured to prevent movement and must not be loaded higher than the sidewalls of the vehicle; drums must be placed on level surfaces in the cargo area and packed tightly together to prevent shifting and tipping. Large structural components must be secured to prevent shifting and bags placed on top (Rule 9.09.04).

150 The transport vehicle must be provided with adequate enclosure to prevent waste from spilling, falling, or blowing while in transit to the disposal site (Rule 7.4). Asbestos transported in an open truck or trailer must be in 6 mil bags within sealed drums (Rule 9.09.02).

151 Following the removal of waste, the truck cargo area must be decontaminated using HEPA vacuums and/or wet methods to meet the nonvisible residue criteria; polyethylene sheeting must be removed and discarded along with cleaning materials and protective clothing, in bags or drums at the disposal site (Rule 9.09.05).

152 Waste shall be wetted and transported to an approved disposal site in leak-tight containers such as two 6-mil plastic bags or fiber or metal drums. Contractor must notify landfill operator prior to delivery (OAR 340-25-465).

153 Transporter must notify landfill operator on arrival; off loading must be done under supervision of landfill operator and shall occur at the immediate location where the waste is to be buried. Waste burial site must be in an area of minimal work activity that is not subject to future excavation. Asbestos specific provisions require that waste be covered with at least 2 feet of soil or 1 foot of soil and 1 foot of other waste before compacting equipment runs over it, by no later than the end of the operating day (OAR 340-25-465).

154 Asbestos specific provision does not allow waste compaction before covering; final cover is compacted.

155 Nonasbestos specific solid waste management regulations require a final cover of at least 3 feet compacted soil graded with a 2-30 percent slope applied within 60 days after portion of fill reaches maximum fill elevation (340-61-042).

156 Open storage or accumulation of friable asbestos material or asbestos containing waste material is prohibited; interim storage responsibility of contractor or owner/operator of abatement. Physical security must be provided and the waste must be protected from the environment (OAR 340-25-465).

157 Friable asbestos must be in a 12 mil plastic bag, two 6 mil plastic bags, or 1 6 mil plastic bag sealed in steel or heavy duty fiberboard drums (Bureau of Solid Waste Management Major Asbestos Standards, Point 1).

158 Separate cells for asbestos waste are recommended. Nonasbestos waste may be disposed in an asbestos cell only after cover is complete and only without distributing the cover or puncturing the containers. Irrespective of the disposal method, cells must be designated for the waste and delineated on plans except where very small quantities are involved or when the waste has been collected as a negligible percentage of other waste streams (Bureau of Solid Waste Management Major Standards, Point 7). Rules require 6 inch cover of nonasbestos waste to be immediately applied (Point 6).

159 Nonasbestos specific solid waste management rules require an intermediate cover of 1 foot in areas where another lift will be placed on top within 1 year (75.26(n)).

160 Initial cover not compacted; intermediate and final cover are compacted.

161 Final cover of 2 feet required within 2 weeks after placement of waste in the final lift; completion includes stabilization of slopes (75.24(xxi)).

162 All asbestos waste must be transported in a noncompaction vehicles which is enclosed or covered with a tarp (Bureau of Solid Waste Management Major Asbestos Standards, Point 3).

163 All asbestos waste must be thoroughly wetted with an amended water solution before being containerized. Requirements include double polyethylene bags at least 6 mil thick which may be securely sealed, metal or fiber drums with locking ring tops for sharp edge components, and 2 layers of 6 mil plastic sheeting secured with tape for large components or structural members removed intact (R23-24.5 ASB, B.8).

164 Solid waste management regulations require that asbestos material accepted at a sanitary landfill be placed at the bottom of the working face and immediately covered with either a minimum of 2 feet of refuse or a minimum of 6 inches of clean fill (10.06).

165 Solid waste management regulations require that an additional 6 inch cover material be applied over the initial cover within 1 week where an additional lift will not be added within 6 months (10.04).

166 Solid waste management regulations require a total thickness of 2 feet of cover material to be maintained on all surfaces when the final elevation is reached, when no additional lift will be added for one year, or when landfill operation is terminated (10.04).

167 All asbestos and contaminated waste shall be thoroughly wetted with amended water before being containerized. Metal for fiber drums are required for waste containing sharp-edged objects. Double polyethylene bags of 6 mil which can be securely sealed are required; excess air shall be removed from the bags prior to sealing with a HEPA vacuum. Large components or structural members removed intact are to be wrapped in 2 layers of 6 mil plastic sheeting and secured with tape (SCRR 61-86.1, Section VI.1).

168 Landfill operator must inspect incoming load for damaged containers and repack any damaged containers in empty drums. Landfill operator must sign trip ticket for return to state by contractor (SCRR 61-86.5.6). Nonasbestos specific solid waste management rules require a 6 inch daily cover (61-60-C).

169 Solid waste management rules require an intermediate cover of 1 foot where the surface will be exposed more than 30 days; final cover shall be applied if future fill is not planned within 1 year (61-60-C).

170 Solid waste management rules require a final cover of 2 feet placed over any completed section of the fill within 1 week following placement of material in that portion (61-60-C).

171 Cargo area of transport vehicle must be free of debris and lined with 6 mil polyethylene sheeting unless waste is transported in sealed drums; drums are to be tightly placed on level surface. Debris on containers is to be cleaned by HEPA vacuums or wet cleaning methods. Large dumpsters must have locks unless temporary storage is authorized. Waste must be transported directly to landfill. (SCRR 61-86.5.5).

172 Truck cargo area must be cleaned by HEPA vacuums or wet methods and polyethylene sheeting disposed in bags or drums (SCRR 61-86.5.6.4).

173 Nonasbestos specific solid waste management rules require the State to inspect each abandoned or closed disposal site annually until it is not potentially hazardous to public health or the environment to ensure the closure conforms to standards (74:27:01:03).

174 Nonasbestos specific solid waste management rules require a final cover of 2 feet (74:27:03).

175 Nonasbestos specific solid waste management rules require that if any former dump site releases liquids or gases that might contaminate surface or groundwaters or create a hazard or nuisance, then all necessary measures shall be taken by the responsible party to eliminate the contamination or nuisance to the satisfaction of the State (Rule 1200-1-7.06).

176 Nonasbestos specific solid waste management rules require a 12 inch intermediate cover on all areas that will be left exposed for over 1 month (Rule 1200-1-7-06).

177 Nonasbestos specific solid waste management rules require a final cover of 2 feet not later than 1 week after the final lift is completed (Rule 1200-1-7-06).

178 Asbestos is regulated as a special waste (Section 289.156). Delivery of the waste must be coordinated with the landfill operator so it can be properly handled and covered when it arrives. Waste must be segregated from other waste for burial (section 325.150); friable asbestos bags or containers must be placed below natural grade (Section 329.126). A cover of 1 foot of earth or 3 feet of solid waste must be placed over the waste immediately (Section 325.136).

179 Nonasbestos specific solid waste management rules for Class I sites must apply a final cover of 2 feet (1.5 feet of clayey soil and 6 inches of topsoil that will sustain vegetation (Section 325.150).

180 Nonasbestos specific solid waste regulations require abandoned open dumps must be closed in accordance with regulations; all solid waste shall be compacted and covered with at least 2 feet of suitable cover material (Section 12).

181 Asbestos shall be disposed of in double polyethylene bags of 6 mil each and which can be securely sealed; if waste contains sharp edged components, use metal or fiber drums with locking ring tops. Large components or structural members removed intact may be wrapped in 2 layers of 6 mil plastic sheeting secured with tape. Clean asbestos contamination off disposal containers before removing them from work area. Prevent discharge of visible amounts of asbestos material into any sewer system (R446-1-8.6).

182 Asbestos waste not containerized as required must be buried immediately upon receipt at disposal site (R446-1-8.6). Nonasbestos solid waste management regulations require an initial cover of 6 inches of earth after each operating day (Section 6).

183 Nonasbestos solid waste management regulations require a final cover of 2 feet of earth.

184 Nonasbestos specific solid waste management regulations require disposal facilities operating without a permit to remove all solid waste and close or achieve compliance with standards (Section 4.2).

185 Asbestos specific solid waste management regulations require that friable asbestos be contained in sealed, double 6 mil plastic bags or encased in 2 layers of 6 mil plastic wrap. Sealed cardboard containers or fiber drums are required for dense waste (Section 8.1).

186 Asbestos is classified as a special waste under solid waste management regulations. Friable asbestos must be disposed of in a special purpose landfill or in a designated area of the sanitary landfill; wastes shall be segregated in designated areas and separated cells; disposal can not be in the active face. The bottom of cells or trenches shall not be within 5 feet of the seasonal high groundwater level. Waste must be hand-place in the trench or cell or other approved means used. Waste can not be buried above the natural ground surface except in area fill type sanitary landfills where other solid wastes are also received and will cover the asbestos material. Only landfills that provide daily cover may be approved to receive friable asbestos and asbestos containing material. Where the wastes may contain other leachable materials, the site must have an approved liner and leachate collection system. A plat of the disposal area must be recorded with the deed of the property. All waste must be covered with at least 1 foot of soil at the end of the operating day. All accidentally broken materials must be covered with 1 foot of soil immediately (Section 8.1).

187 Waste is not compacted until initial cover has been applied. A cell which has been completely covered with 1 foot of soil may be compacted (Section 8.1).

188 Asbestos specific solid waste management regulations require a final cover of 3 feet of soil to be placed over all areas that have not been in use or will not be used for more than 30 days. Areas that have not or will not be used for 1 year must be graded and vegetated (Section 8.1).

189 Asbestos specific solid waste management regulations require crews on transport vehicles to be segregated from the waste. The waste must be accompanied by appropriate manifest shipping papers (Section 8.1).

190 Asbestos specific solid waste management regulations require that friable asbestos be transported in a closed conveyance (Section 8.1).

191 Asbestos must be thoroughly wetted before being containerized. Double 6 mil bags which can be securely sealed are required; metal or fiber drums with locking ring tops are required when waste contains sharp components. Large components or structural members removed intact must be wrapped in 2 layers of 6 mil sheeting secured with tape (Section 2.5.2).

192 Asbestos is classified as a special waste under solid waste management regulations. Disposal of more than 10 cubic yards from a single source must be done at a certified landfill; less than 10 cubic yards may be disposed of at a certified municipal landfill under certain conditions. For more than 10 cubic yards, the landfill operator must maintain records and a 3 dimensional grid system to identify where the waste is buried; inspect the vehicle contents for proper containerization and verification of the content; mist the waste as it is removed and mist the daily disposal cell prior to disposal; ensure that the containers have not been mechanically compacted prior to receipt; and provide employee training. The waste must be covered immediately with 6 inches of appropriate cover material. For less than 10 cubic yards disposed of at a certified municipal landfill, the landfill operator must place the waste away from the working face, but not along a final slope. All other requirements apply except for misting of the waste/disposal cell and employee training.

193 Nonasbestos specific solid waste management rules require an intermediate cover for areas left temporarily unused for at least 6 months but not fully closed (Section 6.702). "Intermediate cover" is defined as 1 foot thick (Section 6-201).

194 Nonasbestos specific solid waste management rules require a final cover with a minimum slope of 5 to 33.3 percent to be applied within 90 days of achieving final elevation; grass or ground cover must be established within 4 months (Section 6-702). "Final cover" is defined as a 2 foot thickness of cover material with an inplace permeability of 10^{-5} cm/sec overlain by 6 inches of material that will support vegetative growth (Section 6-201).

195 Nonasbestos specific solid waste management regulations require that at closure, at least 2 feet of 1 x 10^{-6} cm/sec or lower permeability soil or equivalent be placed on the final lifts unless the landfill is located in an area having mean annual precipitation of less than 12 inches in which case at least 2 feet of 1 x 10^{-5} cm/sec or lower permeability soil or equivalent shall be placed on the final lifts. Artificial liners may replace soil covers provided that a minimum of 50 mils thickness is used (WAC 173-3-4-460).

196 Solid waste management regulations require that asbestos be disposed in a special purpose landfill or a special area of a landfill, by hand, in a lined area. Land records must indicate the location of disposal. The waste must be covered with 1 foot of soil at the end of the day (Section 4.13.2).

197 The waste shall not be compacted before the initial cover is applied (Section 4.13.2).

198 Solid waste management regulations require that the waste be covered with 3 feet of soil if the lift is not used in 30 days; the soil must be graded to prevent erosion.

199 Nonasbestos specific solid waste management rules require an intermediate cover of 1 foot with a slope between 5 and 33 percent for any portion of the landfill that will not receive additional solid waste for more than 6 months (NR 506.06).

200 At closure, a final cover of 2 feet of earth sloped to allow water to runoff must be applied (NR 506.08).

201 Nonasbestos specific solid waste management rules require a 1 foot intermediate cover for any area where waste will not be disposed for 6 months (Section 5).

202 At closure, a final cover of 2 feet of soil, covered with at least 6 inches of topsoil, graded and seeded, is required (Section 7).

TABLE 4. COMPARISON OF REGULATORY BASELINE AND ALTERNATIVES FOR SPRAYING, INSULATION, AND ROADWAYS

REGULATORY BASELINE	REGULATORY ALTERNATIVES[1] PROHIBIT SPRAYING	PROHIBIT INSULATION	ROADWAYS
FEDERAL			
EPA NESHAP (40 CFR 61.140)	NO[2]	NO[3]	NO[4]
OSHA Workplace (29 CFR 1910.1001)	NO[5]	NO	NO
OSHA Construction (29 CFR 1926.58)	NO[5]	NO	NO
EPA AHERA (40 CFR 763, Subpart G)	YES[6]	NO	NO
STATES	YES[7] (6/51)	YES[8] (4/51)	NO[9] (0/51)

CODE: "YES" means that the existing rule contains requirements similar to or the same as the regulatory alternative. "NO" means that the rule does not contain the requirements. For States, the number with regulations more stringent than Federal requirements that are similar to or the same as the regulatory alternative is shown in parentheses.

1 See Attachment 1 for description of regulatory alternatives.

2 Asbestos containing materials that are spray applied must contain 1 percent of less asbestos on a dry weight basis for application on buildings, structures, pipes, and conduits. For spray application of materials containing more than 1 percent asbestos on a dry weight basis on equipment and machinery, the operation must discharge no VE or comply with air cleaning requirements; notification requirements also apply. These requirements do not apply to the spray-on application of materials where the fibers are encapsulated with a bituminous or resinous binder during spraying and the materials are not friable after drying (40 CFR 61.148).

3 No owner or operator may install or reinstall any insulating materials that contain commercial asbestos if the materials are either molded and friable after or wet-applied and friable after drying (except for spray applied insulating materials (40 CFR 61.150).

4 No person may surface a roadway with asbestos tailings or asbestos containing waste material unless it is a temporary roadway on an area of asbestos ore deposits (40 CFR 143).

5 The 1986 rule prohibited the application of asbestos by spray methods in the standard for workplaces and the standard for construction sites. This prohibition was removed as a result of the judicial remand (54 FR 52024, December 20, 1989).

6 40 CFR 763, Subpart G adapts provisions of the 1986 OSHA standard; 40 CFR 763.121(g)(2)(iii) prohibits the application of asbestos by spray methods in school abatements.

7 Six states (Alabama, California, Illinois, Massachusetts, Minnesota, and Oregon) prohibit the spraying of substances containing any amount of asbestos. New Jersey, and Washington do not prohibit spray applications, but place more stringent limits on the asbestos content (0.25 and 0.1 percent by weight). Colorado and Hawaii require additional precautions or equipment controls (HEPA filters).

8 Four states (Massachusetts, New York, Rhode Island, and South Carolina) require that nonasbestos insulating materials be used.

9 Two states (California and Oregon) supplement the NESHAP to specify that the deposition of asbestos tailings on roadways covered with snow or ice is considered "surfacing". No states were identified that ban the use of tailings on temporary roads in areas of ore deposits.

ATTACHMENT 1. DESCRIPTION OF REGULATORY ALTERNATIVES

PROHIBIT SPRAYING. This alternative would prohibit the spraying of asbestos material (except for resinous and bituminous sprays).

PROHIBIT INSULATION. This alternative would prohibit the use of insulating material that contains more than one percent asbestos, whether commercial or contaminant.

ROADWAYS. This alternative would regulate the removal and recycling or disposal of asbestos paving.

TABLE 4A. COMPARISON OF STATE REGULATIONS AND ALTERNATIVES FOR SPRAYING, INSULATION, AND ROADWAYS

STATE BASELINE	REGULATORY ALTERNATIVES PROHIBIT SPRAYING	PROHIBIT INSULATION	ROADWAYS
Alabama	YES[1]	NO	NO
Alaska	NO	NO	NO
Arizona	NO	NO	NO
Arkansas	NO	NO	NO
California	YES[2]	NO	NO[3]
Colorado	NO[4]	NO	NO
Connecticut	NO	NO	NO
Delaware	NO	NO	NO
District of Columbia	NO	NO	NO
Florida	NO	NO	NO
Georgia	NO	NO	NO
Hawaii	NO[5]	NO	NO
Illinois	YES[6]	NO	NO
Indiana	NO	NO	NO
Iowa	NO	NO	NO

STATE BASELINE	REGULATORY ALTERNATIVES PROHIBIT SPRAYING	PROHIBIT INSULATION	ROADWAYS
Kansas	NO	NO	NO
Kentucky	NO	NO	NO
Louisina	NO	NO	NO
Maine	NO	NO	NO
Maryland	NO	NO	NO
Massachusetts	YES[7]	YES[8]	NO
Michigan	NO	NO	NO
Minnestoa	YES[9]	NO	NO
Mississippi	NO	NO	NO
Missouri	NO	NO	NO
Montana	NO	NO	NO
Nebraska	NO	NO	NO
Nevada	NO	NO	NO
New Hampshire	NO	NO	NO

STATE BASELINE	PROHIBIT SPRAYING	REGULATORY ALTERNATIVES PROHIBIT INSULATION	ROADWAYS
New Jersey	NO[10]	NO	NO
New Mexico	NO	NO	NO
New York	NO	YES[11]	NO
North Carolina	NO	NO	NO
North Dakota	NO	NO	NO
Ohio	NO	NO	NO
Oklahoma	NO	NO	NO
Oregon	YES[12]	NO	NO[13]
Pennsylvania	NO	NO	NO
Rhode Island	NO	YES[14]	NO
South Carolina	NO	YES[15]	NO
South Dakota	NO	NO	NO
Tennessee	NO	NO	NO
Texas	NO	NO	NO
Utah	NO	NO	NO
Virginia	NO	NO	NO

STATE BASELINE	REGULATORY ALTERNATIVES PROHIBIT SPRAYING	PROHIBIT INSULATION	ROADWAYS
Vermont	NO	NO	NO
Washington	NO[16]	NO	NO
West Virginia	NO	NO	NO
Wisconsin	NO	NO	NO
Wyoming	NO	NO	NO

CODE: "YES" means the State rule contains a provisions similar to or equivalent to the regulatory alternative. "NO" means the State rule is similar to or equivalent to existing Federal rules.

1 For public sector abatements, spray or trowel applied fire resistant materials must be labeled and listed as asbestos-free material that provides the degree of fire protection required by applicable building codes. Spray or trowel-applied thermal or acoustical insulation material used for patching or replacement must provide performance characteristics equivalent to or better than the original material (Sections 2.1.8 and 2.1.9)

2 Prohibits the spraying of any substance containing any amount of asbestos in or upon a building or other structure during its construction, alteration, or repair (Regulation 11, Rule 2, 11-2-301).

3 The deposition of asbestos tailings on roadways covered with snow or ice is considered "surfacing" (Regulation 11, Rule 2, 11-2-301).

4 No VE from spray-on applications and/or use HEPA filters to clean emissions (Regulation No. 8, Section III.D.4).

5 Employees engaged in the spraying of asbestos, the removal, or demolition of pipes, structures, or equipment covered or insulated with asbestos, and in the removal or demolition of asbestos insulation or coverings shall be provided with respiratory equipment and special clothing (Hawaii Administrative Rules, Section 12-2-2-13(d)(2)(C)).

6 The spraying of asbestos containing material is prohibited. Nonasbestos spray insulation shall not be sprayed in an area open to the atmosphere unless certain precautions (containment barrier and vacuum cleanup) are taken (Title 35, Subtitle B, Sections 228.131 and .132).

7 Prohibits spray application of any asbestos containing material (310 CMR 7.15(f)).

8 Prohibits installation or reinstallation of asbestos-containing insulating material (310 CMR 7.15(g)).

9 Prohibits spraying of any acoustical insulating, thermal insulating, or fireproofing product containing asbestos in any area open to the outdoor atmosphere (by definition, a product contains asbestos if a detectable amount by x-ray diffraction, petrographic optical microscopy or other approved method is present in the product or in any material that goes into the product). Emissions from the spraying, if such spraying is not otherwise prohibited, shall not exceed the amount that would be emitted if the emissions were treated by a fabric filter installation (Rule 7005.1570).

10 Surface coating by spraying on any building, structure, facility, installation or internal or external portion thereof, asbestos or friable material containing in excess of 0.25 percent by weight of asbestos is prohibited (Title 17, Chapter 27, Subchapter 17.2).

11 Damaged areas of fireproofing or thermal insulation shall be repaired using a nonasbestos material (56-14-1).

12 Material containing asbestos, tremolite, anthophyllite, or actinolite shall not be applied by spray methods (437-115-115). Any person intending to spray materials to insulate or fireproof buildings, structures, pipes, conduits, equipment, or machinery shall report to the Department prior to beginning the operation (340-25-465(8)).

13 The deposition of tailings on roadways covered by snow or ice is considered surfacing and is prohibited (340-25-465).

14 For enclosure jobs, nonasbestos substitutes shall be used to patch thermal insulation and fireproofing materials when required and where appropriate (R23-24.5 ASB, B.8).

15 For enclosure jobs, nonasbestos substitutes shall be used to patch thermal insulation and fireproofing materials where appropriate (SCRR 61-86.5.1.4.3).

16 Materials containing asbestos shall not be applied by spray methods unless the materials contain less than 0.1 percent asbestos by weight, the asbestos is a natural contaminant, and objective data demonstrates that employee exposure will not exceed the action level of 0.1 f/cc (WAC 296-62-07713).